ORGAN AND FUNCTION

A STUDY OF EVOLUTION

BY

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TO
MY WIFE
HARRIET CHAPMAN HAHN

PREFACE

Definition is important and needs illustration. Automatic evolution is the production of form and order in nature by the action of force upon inert matter. One virtue this definition of the subject has in common with all others is that it has no content. Apparently we have the sides of a box without top or bottom. What is matter? and what is nature? Also there is mental action without ascertained conditions. It is the train not the landscape which rushes along at sixty miles an hour.

Automatic evolution is the hope of research. One grand dynamic movement throughout the one visible universe and one principle for the understanding, involving as well the action of the mind, prepossesses the imagination. Research is bound to find the immediate, material cause of each event. Each unexplained item is set aside in the hope that further inquiry may solve the remaining difficulty. The practice of setting aside becomes a habit. The distinction between facts which are incompatible with a hypothesis and facts which are distinctly hostile to it is overlooked until a body

of evidence has accumulated which overbalances the top-heavy supposition. The doctrine of the development of nature by resident forces is at that point. Mutation has many advocates, but mutation is fractional creationism. A cord of wood is a cord of wood whether it be cord-wood or kindling-wood. To split an event is not to explain it. Acquired characters cannot be inherited, therefore, the germ-plasm hypotheses. The critical moment of evolutionary changes is to be found in a mysterious, unexplored, infinitesimal world. The question is appealed from the realm of observation to that of conjecture. This change of venue puts the issue beyond the range of observation. And there, unless one is prepared to adopt the notion that a chemical formula is a sufficient definition of life, only a miracle can produce life. This conclusion is usually obscured and evaded by the phrase "unknown factor of evolution." At some moment and in many particulars, in the exposition of evolution, natural characters must be regarded as potencies instead of actualities, that is, as pure conceptions of the understanding. All the threads of connection must be carried around through the regions of metaphysics to connect with the next event. And the whole fabric is founded upon the proposition that order is a form of accident and the lower has the same

content as the higher. The one argument offered to maintain this absurdity is the persistence of force. The influence of this presumption in favor of automatic evolution is too well illustrated by the confession of the chief authority in embryology, Prof. Haeckel. He admits that he tampered with the evidence. The apology is worse than the offence. He puts in a pound of accusation with an ounce of acknowledgment. He says in effect, "I may have been bad, but I have plenty of company." But in that region of investigation, where resemblances are at best vague and inconstant, it is not surprising if men too high-minded to manipulate the facts should find some reflection of a favorite doctrine in an obscure field of research. N rays were discovered immediately after the discovery of X rays.

The achievements of naturalists have been stupendous. They have immensely increased our knowledge of material facts and principles. More than a generation has passed since they abandoned all accepted doctrines and proceeded to build up a science of the world by a rigorous induction of observed facts. In pursuit of that object they have been thrust into metaphysics. Evolution is now both a creed and a tradition. The facts which they have found are so subtile and complex in relation and often obviously arranged for predeter-

mined results that the principle of explanation must be sought in the world of mind and purpose. In the effort to avoid such a conclusion conjecture has been taxed to absurdity until the student is tempted to say, "what a wonderful deal of speculation to a pennyworth of material facts."

A preface is customary, usually unnecessary and always an annoyance. In conclusion, then, let me say, if I were to express my admiration for those naturalists whose views I have ventured to criticise I must write another chapter, and if I acknowledged my indebtedness to them I should be bankrupt of thanks.

B. D. H.

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ORGAN AND FUNCTION

A STUDY OF EVOLUTION

The thread of Ariadne which traverses all the labryinths of nature and thought is the doctrine of evolution. The ingenious eye detects its presence in the multitude of analogies, resemblances and adaptations of living forms, their organs and members. There are confirmations everywhere. A glance into a cage of primates brings conviction to the casual observer. Already the immovable eye of the animal kingdom begins to play in its socket. Man supreme among the hunted shall have this advantage also over his competitors, "armed with tooth and claw," that with rigid head and neck he shall be able to survey the prospect with rotating eyeballs. This mobility shall initiate the higher and more subtle function, the telepathy of the human glance. Further comparison of members verifies the hypothesis in its broader implications. Wings fall into a consecutive series of resembling forms, from the swimming wing of the penguin to the immovable vanes of the wandering albatross. The mind once possessed of this titanic surmise finds that every member can be construed by sequence.

The soaring birds,—condors, eagles, buzzards and hawks,— have the humerus extended, and the wing is capable only of the slow shoulder sweep. Geese, ducks, grouse and pheasants, with a shortened humerus, have attained to the more nimble elbow action. But the turbine-driven lighter craft, the hummingbirds, have the finger and hand lengthened while the shoulder and arm are almost suppressed to secure the vibratory action of the wrist. These garden meteors belong to the swifts and swallows, but the short bill and wide gape of the family have been modified into the delicate forceps of the species. Here adaptation has been applied with the nicety of watchwork. The avocet, for instance, affects flowers with staggered corolla tubes. Fastidiousness has recurved his bill for the gratification of his exacting tastes. The horny member has been plastic to the touch of wind-ruffled petals. The animal structure has surrendered its rigid member to be remodelled by the most fragile of vegetable tissues.

Having made our confession we are haunted by a doubt. Our chosen illustration has suggested a problem. Mechanical laws, to speak relatively, are the rigid framework, the bedplate of the operations of Nature. The stronger member is the vehicle of greater force. There must be some precedence among natural laws.

There must be law among laws. Any hypothesis must have a working basis for movable parts. If no realm of causation is more fundamental than another, and if more highly specialized forms are continually and directly disturbed and remodelled by the lower, all major inferences yield like the "compression members" of the Quebec bridge. Here we have the rigid beak of the bird modified by the caress of the flower. Animals are not considerate of the interests of the vegetation on which they feed. The Kalaza or flying fox "tears out and devours the three inner petal structures of the Freycinia," the Java creeper. Cattle, horses, bears, raccoons and crows work havoc in a cornfield. The avocet cannot see into the corolla; for in that case he has no advantage in his recurved bill. He is not confined to those flowers only which have bent corolla tubes. His crooked bill is a disadvantage when he forages among other blooms. Straight-billed birds force an entry. His ancestors rioting among the same flowers were successful or his species would have ceased to be. It is not easy to see how there was a principle of selection among the birds to confirm the variation, a recurved bill, which is not a, "life and death," advantage. It appears to be a kind of evolutionary flourish and biological inconsequence. Is Nature feminine?

CHAPTER I

BEAUTY AND DESIGN

These glittering, glancing sprites, whose paths are noonday lightnings, raise again a serious issue which was once concluded,—the question of beauty in nature. Did the female argus pheasant preside at the selection of the markings of the male? Was it butterfly taste which chose the streaks of trickling green fire on the velvet wings of urania leilas of Peru? Are we indebted to the befeathered ladies of the tree-tops for the gorgeous and particular patterns of standard-wings, rifle birds, parrots, toucans, coquettes, sappho-comets and the fiery topaz? By the same authority have we the song of the lark, the bell-bird, the nightingale and the mocking-bird, who can play any instrument of the woodland orchestra?

There are two conditions of the relation of beauty, the refined object and the taste to appreciate it. How such delicate adaptations were produced has been a subject of much research and discussion but the taste which umpires the result has not been so carefully investigated. Recently the aesthetics of insects has

been tested by experiment. The wings of moths (Prometheus) have been painted with unfamiliar colors, again the wings of the sexes have been interchanged and finally they have been removed, but the mating insects have been indifferent to these radical measures. The splendor of these dwellers of the night has no influence with the creatures themselves. Mandrills on the contrary are adorned with gorgeous blue and red callosities, yet they are exposed to unfavorable comment from without the cage. The imputation to birds and insects of the taste and discrimination necessary for an evolutionary explanation of form and color which surpasses our own powers of invention who are the judges of the art and the formulators of theories of their being should have staggered credulity and put to shame the intelligence which presumed to criticise their understanding. This supporting hypothesis of natural selection, therefore, has been disputed. Beauty as a motive of sexual selection and a part of the evolutionary argument has been definitely set aside. The scientific verdict is, "We do not know." The subject is ignored. Rash people might be tempted to look for design in nature.

Taste, then, as a principle of the understanding of birds and insects which had been inferred from conditions of form and color and attrib-

uted to them is an unwarranted assumption. But does beauty exist as a principle in nature? Mr. Darwin says, that birds and insects, "have been made beautiful for beauty's sake." He further explains that, "the idea of beauty is not innate or unalterable." It is not a principle of fact but of thought. It is a mode of utility, is not addressed to man and is the illusion of our sentient pleasure. "Flowers rank among the most beautiful productions of nature; but they have been rendered conspicuous in contrast with the green leaves, and in consequence at the same time beautiful, so that they may easily be observed by insects. I have come to this conclusion by finding it an invariable rule that when a flower is fertilized by the wind it never has a gaily colored corolla. Some plants habitually produce two kinds of flowers; one open and colored so as to attract insects, the other closed, not colored, destitute of nectar and never visited by insects."

When therefore, the autumn landscape of this country looks like a fallen sunset, and every glade and fence corner blazes with sumac and scrub oak, the bees should strike work. The flowers do not then stand out "in contrast with the green leaves." The closed gentian also should take in its useless blue signal on behalf of this "invariable rule." For readers and students the statement of Mr. Darwin has been

final, but for naturalists it has suggested experiment. They would find further if insects were qualified by vision and taste for the role here assigned to them in the economy of plants. They would ascertain if flowers were advertisements or properly objects of beauty. In a hundred experiments to test the preference of bees in the matter of color, Sir John Lubbock found that bees preferred green to all other colors except blue. Mr. Darwin supposed that flowers were colored to distinguish them from green. And plain glass was chosen by the bees before red, white and yellow, the predominant colors of flowers. It follows that bees are not persuaded by vivid colors. Further experiment has raised a different question, Do insects depend upon sight or smell or some unknown sense to find the blooms; for bees failed to find them when covered by glass but came to them when the corollas were plucked off. Blow-flies also are not attracted by color or form. It would appear, then, that in the matter of food-selection also color does not guide the insects.

On behalf of the Darwinian theory Sir John Lubbock argued that since blue flowers were comparatively rare and since they occurred in orders in which red or yellow were the prevailing colors, blue was a later creation of nature than red or yellow. The blossoms of these plants were originally red or yellow. Blue

flowers, then, on account of their rarity and affinities, are later forms and the preference of bees for blue is a more recently acquired taste. If, therefore, Sir John Lubbock had argued the taste of bees instead of the affinities of blue flowering plants he would have come to a different conclusion. The education of bees had been accomplished with red, white and yellow before blue flowers appeared and these colors are still predominant. According to the principle of utility and the hypothesis that color is an advertisement, the bees should have preferred any color to blue with which they had little experience. The evolution of taste should keep pace with environment. But taste has outrun experience. The bees have taken the initiative out of the hands of environment and amended their curriculum. Taste instead of use and wont has determined their education. The argument that the rarity of blue shows that it is a later development makes for the evolutionary hypothesis, but the omitted argument that bees prefer the new color makes against it. When one part of the experiment is linked to the theory the other comes away. While one end of the plank is spiked fast the other pulls out the nails.

One of the dangers of observation is attention to a single feature. The broad statement of Mr. Darwin appeared to settle the dispute.

Naturalists usually rest their case with primary colors. All other tints and hues, the color-patterns, markings and the infinity of graceful forms, equally important elements of beauty, are disregarded. This narrow method of investigation becomes a discussion in form but an evasion in fact.

Birds and animals appear to have no power to perceive drawing or painting. Mr. Darwin indeed applied his supposition to the ball and cup design upon the feathers of the Argus pheasant. There is no evidence that animals can perceive representations upon a plane surface. No dog barks at Landseer's paintings. The birds we are told pecked at Appelles' painted grapes but then they were Athenian birds.

That, "beautiful objects were created solely for man's gratification" does not test the reality of beauty as a principle in nature. In the constructive arts beauty is born of utility. Architecture is founded on the homely laws of "mass, stability and durability" and rises through symmetry, proportion and the refinement of lines, surfaces and members into eloquence and style. Ornament for its own sake is an excrescence, and when it masks the purpose of the building it is an offence. Therefore "the beautiful volute and cone shells of the eocene epoch" and "the gracefully sculptured ammonites of

the Secondary period" are beautiful according to the laws of our constructive arts without any sign that "they were created that man might ages afterward admire them in his cabinet." If man understands them at all, by his own pupilage and adaptation he should admire them. It should be true of man also, and he "saw that it was good."

But does nature always unite the useful and the beautiful? Is she always bound by our constructive laws? Does she never subject utility to beauty? Is there not only design but also eloquence in nature? Are there no signs of pure aesthetics in the world? Are there no evidences of the colorists delight in splendor?

The luminous feather of the hummingbird, like the bird itself, is a triumph of natural art. Other birds are made glorious with colored feathers, and some, like doves and grackles, have a sheen or iridescence, but these little Rajahs add gems to their uniforms. Seen at one angle their flaming plumes are sometimes a sooty black, at another they are brighter than rubies or sapphires. They are optical devices finer than diffraction gratings. The plumage of the world shows that they are unnecessary, and nothing in environment or the constitution of birds can account for their brilliance. The magnitude of the assumption that they arose by

spontaneous variation or simple "fluctuations" will appear when we attempt to discover the optical device by which pure flame colors are produced.

When 39,000 waves of light to the inch meet the eye we see red; when there are 41,000 to the inch the color is orange, and when the vibrations number 59,000 to the inch the color is violet. When irregular white light strikes a surface divided by parallel bands or grooves 1-39,000th of an inch in breadth the reflected light will be red. A variation of 1-15th of the width of these little terraces will change the color to orange. When we apply optical laws to feathers we may form some notion of the art and thoroughness of the design of the instrument by which the waves of light are rearranged. There are perhaps a score of recognized tints and shades of red. If then the grooves or corrugations of the ruby throat feather should vary 1-100th of 1-39,000th of an inch that shade of red would be changed. To secure a uniform shade the device must be rigorously applied to every barb of every feather of the throat of the bird. When the color is violet and the scale is 1-59,000th of an inch the severity of the conditions of this supreme invention approaches the absolute. By our microscopes we are enabled to see the markings of diatoms. These markings, we suppose,

are organs. They are not applied to produce color or ornament of any kind. They are not devised for the world of sense. But a more minute design is employed to embellish the gross feather of a bird and produce an astounding effect in the sensible world.

In both size and shape these infinitesimal bands are subject to the same rigorous conditions. Now this description of the apparatus by which the illumination of the hummingbird feather is effected is an hypothesis, a conjectural representation founded upon the laws of optics. Whatever the actual device employed, the laws of color dictate just such prevailing minuteness and rigor of design.

Under the miscroscope a green feather is a dead palm-frond. The barbels seen obliquely "frost" like a silk rug, that is, the irregular surface reflects the light in irregular waves. Viewed with a transmitted beam of sunlight, the membrane of the barbels is traversed with a drawn network of minute veins. These veins are too gross to reform the waves of light and regulate them. The scale is 47,480 to the inch to produce the green illumination of the plume. It is by surfaces marked in this manner, by lines finer than these which the microscope reveals that we have blue and purple and extreme violet,—the whole spectrum and many blendings of color upon the feathers of a bird. But

the marvels of the color scheme have not been exploited by a discussion of the mechanical device. The stiff, rufous ruff of the coquette has a green polka dot in the end of each feather. The design is as exact as if struck by compasses. Imagination reels in the attempt to figure the art applied. Generalizations about environment and spontaneous variation and survival of the fittest and female preferences are mere irrelevances when the micrometer apparatus and its prodigious application and effects are realized.

But chemistry suggests a more minute alternative to the theoretical explanation under consideration. Although borrowed from a different realm of natural law, it will serve to give emphasis to this departure from biological usage to enhance the splendor of these birds.

If the description of an infinitesimal washboard device for the regulation of light is to be trusted the apparatus is wonderful and the evidence of painstaking purpose convincing. But it is possible that the instrument lies deeper still in the infinitudes, is of a different character and is a more highhanded violation of biological precedent. Gold is combined with glass to make ruby glass. The gold is dispersed in the glass in particles too fine to be observed directly by the ultra-microscope. Its presence is detected by the aura or blink of the

particle. How these dispersed particles produce a red light is a mystery. Compared with this colloid dispersion of gold the theoretical explanation given above represents a rude and clumsy device and the markings of diatoms are immense. Still to doubt the reality of beauty in nature when effects are produced in the sensible world by instant recourse to the infinitudes may be a mark of scientific caution but it is also a display of credulity, a belief that nature can produce contrary to precedent, at random, by spontaneous variation, a new device of infinite refinement.

Beauty, then, as a principle in nature is perceived only by the human understanding. The ornaments of birds were not invented or modified by their taste. Equally divided with regard to sex, as they appear to be, their choice of colors and patterns would not affect the character of the species. That their choice of mates is determined by beauty or song has long been assumed but never proved. Not an instance of such selection has been recorded. Insects are indifferent to their own beauty and are insensible to the colors of flowers. Mandrills so far above them in the scale of being rejoice in offensive excrescences. But nature becomes ingenious in her appeal to our taste when she searches the abyss of the infinitesimal to devise a triumph of art in her masterpiece, a hum-

mingbird feather. What theory demanded experiment has definitely and particularly refuted. If beauty is an illusion of our emotions as Mr. Darwin remarks, "it obviously depends upon the nature of the mind, irrespective of any real quality in the admired object," the stupendous scheme of embellishment we imagine we observe and the unnecessary refinement of natural forms are figments of the understanding. But if these qualities are real, beauty was intended for man's enjoyment alone, and color, shape and proportion as an advertisement to the insects and the means of food and sex-selection are discredited by experiment and abandoned by naturalists.

Beauty in nature opens the door to the profoundest inquiries of science. When Mr. Spencer in his famous definition of life associated the fortuitous and definite he brought contradictory ideas together and begged the question at issue. Accident is not order on any terms nor by any process. The first item of discussion is, How does sense lay hold of nature?

There is rhythm in nature. Her greater masses deceive us by their bulk. But there is a working toward contour and curves in the rugged hills. There is a subtle and various rhythm in the branching of the trees and a more evident one in their blossoms. Waves have a

rhythmic tendency. Discharging liquids become whirlpools by a rhythmic calculable law. Periodicity and recurrence are stamped upon star-drift and snow-flakes alike. Rhythm becomes form and proportion in crystallization. Here is the beginning of aesthetic models. Matter is built and endowed according to mathematical principles. The atom is a system of revolving corpuscles whose mass, force and motion are matters of computation. Molecules are proportional combinations of atoms, and the elements which they compose have a numerical relation according to Mendèeleff's law. Its blanks have been regarded as prophecies which further discoveries have fulfilled, and radium, helium and polonium have taken their place in the table of elements according to expectation. Nature is rhythmic, that is mathematical.

Music, the creature of aesthetics is mathematical. The ear knows when the tone is true, but the uninstructed man does not suspect that the ear is also a mathematical instrument. The ground tone of 100 vibrations can be combined only with its multiples, that is with its harmonics. A bad tone can be corrected by arithmetic. The diatonic scale with its irregular intervals is the element of a higher recurrence, of a higher mathematical combination. It is a rhythm of greater amplitude. Yet higher, more complex is harmony, which is rhythm of a

grander period, and a more intricate numerical combination. What the ear hears as tone is also a mathematical association of vibrations. The ear perceives neither vibrations nor mathematical relations as such, but we can give mechanical demonstrations of this theory of tone and harmony and sequence. The mathematics of color, applied above in the discussion of the colors of hummingbirds, implies that the aesthetics of vision is subject to the same laws. White light is a jumble of ethereal vibrations. It is relatively of less importance to the sense of beauty than red or blue, regulated and uniform vibrations of the ether. Mathematics pipes and thunders to the ear, while with a finer medium of vibration it advances into light and color, provokes vision and awakens our aesthetic sense with the properly attuned instrument, the eye. We have translated musical tones in terms of vision. We have found that so translated they are still things of beauty. Is it but a coincidence and therefore irrelevant that true tones are all functions of the sinusoidal curve, which can also be determined by mathematical formulae? Perhaps the instinct of Dr. Weismann was right as he sought to build up vital elements out of simpler units, but his error lies in the calculus he employed. The simple arithmetic of chemical proportions is inadequate. It may be that only the reckoning of a higher

mind can write the formula of life. The members and contours and motions of living beings have mathematical functions. This felt rhythm of things has its part in the fantastic speculations of Mnemic evolution. It is plain that matter as raw stuff is inconceivable. Until it is brought under mathematical laws it cannot be known by us. Chaos is only the negation of order. "Let there be light" involves mathematics. It is the fundamental theorem of the cosmos. And logic is but indefinite mathematics. The line and plummet have been applied to everything. Grace, everlasting variety, an element of the highest beauty, yields its secret to our higher formulae. If we could frame a divine Principia, the cataclysms of nature could be resolved by our principles. We work by arithmetic an algebraic problem. It is our calculus which is inadequate. Our reckoning fails to explain the irregular hill-slope. But when we see stairs cut in the rock we recognize the work of a laborious mind. We see that a mathematical being has been there beforehand. Our simple arithmetical principles shout to us from every tread. We see design; for the reckoning is our own. The hill slope eludes our understanding at first only because our principles of reckoning are elementary. In all our further attempts to explain matter and the world we but aspire after a higher calculus.

Mathematics is the frame of things and the hall-mark of mind.

Our senses are detectors. They respond to vibrations. We cannot experience matter at rest. Mathematics is the law of material action. We live not by blood flow but by pulsation. All our grand action is supplied by rhythmic heart-beats. We are a kind of music. Man is himself the symphony of the spheres. And the secret, intelligible principle, of the beauty he finds in nature is mathematics. But here is the marvel of the sense of beauty. Our pleasure in the blue of the sky has no relation with vibrations or mathematics. The mental experience lies in a world apart. The note loses its charm when we fix our attention upon vibrations and harmonics. We can verify the tone or color and we can reproduce it by our apparatus, but our delight transcends all apparatus and the laws of sound. If mathematics is the mark of mind,—and can it be the mark of anything else?—this is the mystery:—nature furnishes vibrations under mathematical terms to provoke our joy in motion, color and sound, —magical, transcendant effects in the world of mind. It is like making motions on earth to light up dark stars in Orion. Everything is resolvable but the spiritual, aesthetic sense, which has no commerce with the kind of reality which excites it.

The question before us, Is there beauty in nature or only in our estimation? is susceptible of a cogent answer. We have seen that the aesthetic sense belongs to man alone and that color in nature does not subserve the interests of food or sex selection. We also find that nature is vibrant, rhythmical and mathematical. We know that mathematics is the mark of mind. These abstract principles are latent in things and in human reason. We see that various kinds of receivers have been built into the animal anatomy, marvellously adapted and attuned for their wireless response. But we find that the aesthetic experience, compared with its occasion and sense organs is transcendental. There is beauty in nature because the vibrations, the occasion is there. Those vibrations are mathematical, rhythmical, intelligible. The law is a natural, universal law. Nature is therefore ordered and resonant and figured in itself. These rhythmic vibrations, these colors of flower and insect and bird are addressed to man; and, in as far as aesthetic pleasure is concerned, they are addressed to him alone. By the naturalist's supposition we must presume on the contrary that the sense organ, the consummate instrument, is molded and directed by the elemental mechanical vibration, that is, that the law of its being is without and beneath it or that, in its development, what it is not has

power over what it is. Only so can the ear of the fishes become the ear of Beethoven. There should be no aesthetic sense on these terms, no translation of vibrations into beauty. They should be apprehended as vibrations. Beauty then is both a principle of fact and thought and exists in nature for man alone.

CHAPTER II

UTILITY AND NATURAL SELECTION

A great nauralist, Mr. Francis Darwin, son of a greater, with praiseworthy fidelity and some annoyance remarks, "It is the present fashion to minimize or deny altogether the importance of natural selection." It may be the fashion but naturalists have the effrontery to argue their pretensions as follows,—

Natural selection can come into play only after variation has provided the opportunity for struggle between individuals. Natural selection may enhance advantages already conferred upon species by variation. Specific characters uniformly prevail over characters peculiar to the variety. Descendants relapse to the type of the species. Useless characters are preserved as well as useful characters, and sex ornaments persist although they handicap natural selection. Utility, the touchstone of evolution, is openly set aside, demonstrably ignored, in the artistic perfection of mimetic forms. Mimicry is not a mere exception and curious incident of development. It strikes

down the fundamental rational principle of evolution, utility.

When Nature specializes, as in the imitation of one form by a being of another form and order as long as that imitation is serviceable to the mimic she has not violated the necessary principle of utility. If her work is beautiful that beauty must be merely incidental to utility. If the imitation is perfected for its own sake, if she follow her pattern form so thoroughly that a less accurate copy would deceive an insect, bird or animal, the natural enemies of the species, the imitation is a work of purpose and taste. It appears to be the sign of personality in nature. The dead leaf insect (Kallima) is the most familiar illustration of this overspecialization. The cloudy discoloration of the faded leaf, even the mold-spots of decay are reproduced. When the insect perches, its abdomen touches the twig like the stem of a leaf; when pursued, he sits tight. His instinct matches his form. He "plays possum." Some varieties of praying mantis match the flowers they frequent as perfectly. Nature has dealt fondly with those insect demons and arch hypocrites. They beguile botanists and zoologists as well as the birds. One species from South America imitates the color, shape, and quaint distortion of the petals of a white orchid. Another Burman species, follows so precisely the

pattern and colors of a blue orchid that it deceived the botanist. The "walking-leaf" (phyllium siccifolium) changes its appearance with the seasons. In the wet season it is green, in the dry season it yellows and its leaf-like appendages are bent and distorted. This change of appearance to resemble the half-dried foliage is useful. It is a mimicry which keeps within the bounds of theory. But when we examine the shape, color, proportions and markings of the insect we discover that the pattern is minutely followed, beyond the range of the perceptions of any bird. Here are the veins of the leaf. They meet the midrib at the proper angle, are exactly spaced and join the mid-rib with a precision that only the specialist in botany can appreciate. Utility as the principle of imitation has been cast aside. Natural selection has been applied to reproduce the model. It cannot be that birds are such botanists that a mistake in the insertion of the veins in the mid-rib will betray the cheat. This mimicry is directed by taste. Otherwise we must revise our notions of the botanical instinct of birds.

Overspecialization of kallima, the viceroy, walking-sticks, praying mantis and other mimetic forms is a violation of nature's practical rules. It is devotion to aesthetics, art for art's sake. It is preraphaelite thoroughness. It is

the same spirit which invented the hummingbird feather. But if devotion to an alien principle is bad, what shall we say of provision of unnecessary organic devices? What if animals are constructed with an eye to mortuary tables? What if insurance as well as economy is kept in view? What if the maker throws in a spark plug or, better still, an extra emergency brake?

Two filaments of the vagus nerve descend to the heart. They have an inhibitory, that is, a restraining function. If one filament be cut the animal suffers no inconvenience. The dog is hale and hearty as ever. But if both nerves are severed the heart action is accelerated and he dies by congestion of the lungs. Now the bilateral structure is necessary to animals. Without it they could neither stand nor go. Wherever it is an encumbrance natural selection demands that it be surrendered. It cannot be maintained in the struggle for existence, much less introduced. One filament of the vagus nerve was sufficient if nature has not considerable latitude in her provisions. Accidents to the filaments which regulate the heart are so rare that this duplex part can have no influence upon the fortunes of the species. How were these two filaments invented and how were they maintained if nature is not predisposed to provide for remote contingencies and to supply devices of doubtful utility to the species?

The heart is regulated by an escapement of accelerator and depressor nerves. Two accelerator filaments also descend to the heart. Here is the same duplication of parts to meet almost impossible contingencies. But in addition to the provision of extra parts accelerating fibres are combined with the depressor filaments. Still more remote contingencies are kept in view; for before they enter the heart these filaments of control are threaded through ganglia of the sympathetic system. Should the nerve centers in the medulla oblongata become exhausted the nerves are reinforced by these subordinate centers. This is yet another safeguard against remote contingencies. When a man dies a lingering death, functions undergo a morbid analysis. First, the cerebrum is darkened and the mind is obliterated. Gradually the motor centers are put out of commission in descending order from the brain to the spinal cord, from the spinal cord to the sympathetic ganglia and from these relay centers to the intrinsic centers in the organs themselves. In the process of exhausting the involuntary centers some important conditions of life are reversed. When respiration becomes heavy and stertorous there are pauses and the heart ceases to act. The blood, surcharged with carbonic oxide, which is fatal to the normal system, stimulates the involuntary

center and respiration is resumed. Until these centers are exhausted the man cannot die. The carbonic oxide in his blood will discharge them again and again. By an orderly death the last spark of the accumulators must be used up. What profit to species, that is, for reproduction is there in this arrangement of check and countercheck to the mortal process? How did natural selection, always the selection of a whole individual, ever approach the conditions? How were duplicate parts selected? How were these nerve filaments threaded through alien ganglia? How were fibres of opposite functions woven into a filament of common functions? Here the remotest possible contingencies and morbid conditions are taken into account. It does seem that automatic nature with such a task in hand would make many blunders and under conditions of vital trial would have eliminated these redundant contrivances which can have no reproductive value. In the exercise of her constructive and economic power nature has overreached herself. Here also she has most marvellously overspecialized. Critics of evolution do not object first of all to natural selection, but to preliminary theoretical selection, that is, to the selection of favorable instances. In the presence of the facts evolutionary discussions of natural selection should be entitled, Some Easy Lessons for Beginners.

The remote possibility of accident to one of these accelerator or depressor filaments precipitates a dispute between the carpenter and contractor. Insurance companies and athletic trainers make strict examination of the size as well as the health of the various organs. Ample lungs, heart, kidneys, in their estimation, enhance the force, vigor and longevity of the organism. But, says the surgeon, according to the theory of natural selection, such a margin of safety, if provided at all, should be an encumbrance to the species and a tax upon the vital resources instead of a source of power. We prove by vivisection that there are six feet of unnecessary small intestine. There is not much excuse for a colon. The stomach can be dispensed with. One kidney, nine-tenths of the thyroid and adrenal glands, over half of the liver and much of the lungs are superfluous. The vermiform appendix is about gone and the gall bladder is going, and if the thymus gland is not extirpated in man at twelve years of age he has his death warrant. In the exercise of a principle of economy some of these redundant parts should be eliminated or their proportions reduced with advantage to the organism.

The vexed question of naval architecture troubles evolutionary discussions. The relations of engines, hull, armorplate and guns is

not a matter of finer calculation than the proportions of organs. But nature inclines much more to provide a wide margin of safety and cruising radius. How she accomplished her purpose, and fulfills her plans and freights her organisms with such a mass of commonly useless materials in the presence of her severe demand for the immediate test, the survival of the fittest, we cannot understand. In all these provisions of a margin of safety she cares for the well-being of the individual more than the type, and she does not automatically, that is, blindly apply the law of utility.

Natural selection must be restrained in another way to fulfill higher ends. Characters and organs indispensable to the perfected form must be produced and preserved through the earlier stages of their development when they are useless to the species. The battery of the torpedo, the electric eel, is a familiar illustration. There are innumerable instances of the practice. It appears to be an act of foresight which can thus suspend the law of utility and preserve the unfit for a future service.

Natural characters cannot be produced by variation in a single direction. They are complex. There must be concomitant, co-ordinate variation. Multiform variation is the basis of natural selection, that is, the selection of complex characters. Moreover, not only must ele-

mentary characters be preserved, but also when a valuable character has been formed the struggle for existence must be suspended that the character may be fixed. Isolation which arrests the struggle for existence is made its corollary. We find, then, in an environment where life and death conditions prevail as the test of a real character, the most important characters of the perfected plant or animal must survive, provided with a great margin of safety, through indefinite periods of vitally exhaustive trial and that the process must be arrested to prevent continuous variability and make permanent the acquired character. To accomplish all this nature must furnish the right variation, at the right time, for long periods and then turn on and off the power at the right moment. There must be a recurrent cycle of variation, selection and isolation. The struggle for existence must be alternately commanded and called off.

We shall see later that variations revolve about a mean and do not tend to accumulate in any direction. Extreme characters are few, and, as the mean are approached, the representatives are more numerous. Now since plants and animals are notoriously indiscreet in their nuptial arrangements, the extreme characters are swallowed up by continual crossing. Specific characters prevail over varietal. It fol-

lows that species are provided with a double brake instead of a motor by natural selection. If we arrange our procession of species in perfect order although Michel Angelo may command it to march it stands like Donatello's statue.

Species may be considered as a group of characters which have been tried and established under a life and death stress of environment. Considered as a group they are characters tried severally and in combination. Species, therefore, are doubly the product of the severity of restriction of their environment. Under these stringent conditions change of environment should be fatal to any species.

The situation is not relieved by the discovery that nature advances her creatures by leaps, that is, as sports. The classical, decisive instance is the variable evening primrose discovered by Prof. DeVries. If it is hard to account for species by gradual accumulation of acquired characteristics it is yet more difficult to understand a transformation in toto and the survival of the new, untried form. Mutation belongs with the metamorphoses of insects as an operation to be rationalized. Of the modification of Arthropods (crustaceans and insects) in their several moults Weismann asserts, "These new or transformed parts are formed before throwing off the old chitinous

shell. . . . They must thus have arisen in the ancestors of our modern Arthropods in the same way, that is not by a gradual modification *during* use, but by a slight, sudden transformation *before* use." (Ev. Th. p. 82.) Prof. DeVries is positive that he had discovered the manner of evolution in mutation. He also discovered "ever-sporting varieties," that is, plants which have ever varying characters whose variations "occur within definite limits." How can he be positive that he has not discovered the beginning of an analogous closed circuit in this sudden variation of the evening primrose? His views logically imply preadaptation of species, as we shall see when his theory of germplasm comes up for review. His completely formed species also must be submitted to the struggle for existence and the survival of the fittest. He has also confused the subject by his discovery of "physiologic units." "Thus color is not a character belonging to any single organ or cell nor is it bound to a morphologic unit; it is a free physiologic quality. It is not localized but belongs to the entire plant. If we wish to assume for its basis material, representative particles, those particles must be supposed to be diffused throughout the whole body of the plant." So, then, while science has been particularizing, while investigation has been sin-

gling out functions and tracing particular organs and their special structures, nature generalizes; she reaches out her big, clumsy hand and blurs the fresh picture with one heedless smear. She indulges in somatic variation, the change of the whole organic fabric. She defeats our reasoning by prearrangment and arbitrarily confuses the elements with which we have to deal.

Finally, acquired characteristics cannot accumulate. If specific characters prevail over varietal, does it not follow that generic characters are more stable than specific characters? Each step backward increases the barriers and more clearly affirms the permanence of species. But this argument is superfluous. Biologists agree that the evidence is against the doctrine of the inheritance of acquired characteristics.

Evolutionary research looks for mechanical causes and utilities. One object is the law of the persistence of forms, the other, is the law of their origin. Immediate, efficient, mechanical cause is assigned for the appearance of variations and utility is equally the law of their permanence. Mechanical cause without the principle of utility cannot explain natural characters. In an easy environment utility is not rigorously applied, but in periods of stress and struggle, without which there is no selection, no life and death judgment, disused parts and

"indifferent characters" must be eliminated. Natural selection must be fatal to the possessor of the unadapted character. If the struggle for existence is not carried on with lethal weapons adaptation is without evolutionary power.

Without the principle of utility nature is given to blind slaughter. It is a life and death issue for evolution. Utility is determined by a threefold test;—A particular character or part must have an advantageous function, That particular part or character must be in harmony with other parts and functions, and There must be a general correlation of the individual with the environment. But utility is disregarded when useless characters persist. That organism has considerable liberty which can carry superfluous parts and characters, like the milk-weed butterfly, and indulge in mimetic flourishes and cumbersome sexual ornaments, with a great margin of safety, and retain inchoate parts against a future utility, and prepare checks and counter-checks for the mortal process. Mr. O. F. Cook's statement is a fatal thrust, "Evolution is not caused by the struggle for existence, nor limited to characters of environmental fitness. Harmless and even harmful characters may be acquired by species in the same way as beneficial adaptations." Isolation as a part of the cycle of variation, selection and isolation, as a necessary condi-

tion for the fixing of new characters, is a temporary suspension of the law of utility, the imperative principle of a "vera causa," an immediate, efficient, mechanical cause. By these presents utility is no more a law of biology than is beauty. It is not more evident nor is it more constant nor is it more deeply seated. Natural selection fails to select on the word of naturalists. When we find, further, that variations revolve about a mean, that extremes are eliminated by crossing, that no tendency of departure from type has been discovered, that species characters prevail over varietal characters, and when species itself must be regarded as a complex of characters determined under the sway of environment yet can be translated from environment to environment with advantage, it is plain that selection does not rigorously select useful characters, that at times it suspends the law and again it reverses it. According to these observed results of natural selection there is no opportunity for evolutionary advance. But there is worse to follow.

Concomitant variation, which logically implies mutation, which also suggests somatic inheritance, the inheritance of total variations as compared with variation of parts, must be surrendered in the presence of vestigeal organs. The bond of concomitance

must be loosed by natural selection before any part can be reduced or disappear. The part must be selected out of the harmonized organism in spite of correlations of every degree and kind. Natural selection which is to account for progress and co-ordination of parts must also provide the principle of regression and apply itself to surgery of these same correlated members, organs and characters. Natural selection is, therefore, an equivocal principle of evolution. Roux puts the reality of the organism as a biological entity in jeopardy when he assumes a "battle of the parts" to account for the disappearance of disused members. The organism at the same time is to be a wonder of correlation and at enmity within itself. To meet this critical emergency Weismann suggested panmixia, the general crossing of individuals and the gradual reduction of the disused part by occasional negative variation, that is, decrease in size and organization. He says, "By panmixia I understand the effect of the cessation of selection in respect of some part of the organism. If it is true that forms fitted to exist arise by the selection of the fittest, the maintenance of such forms must depend on the constant weeding-out of the less fit. The cessation of this constant conserving selection must therefore necessarily result in the decline of the part in question from the height of its adapta-

tion." But that assumption was not enough. To save the day he proceeded to put in question the value of isolation as an advantage to the newly-formed species and reversed another important mode of evolutionary reasoning. He contended that species must be maintained in their integrity by the same struggle which developed them. The severity of conditions must be constant. But if species are as unstable as his suggestion implies a constant environment should be detrimental to species. On the contrary the protests of biologists since the day that natural selection was propounded have swelled into a general clamor of dissent. Their observations convince them that in most instances the stringency of environment occasioned an indiscriminate slaughter; that maimed individuals in ordinary conditions survive; that a favorable environment lends energy to species; that adult forms after the weeding-out process of the struggle for existence has been applied are still as various as they were before that process was instituted; that the imago of many insects is more highly specialized than the larva or pupa although the imagos are ephemeral, perish in a day; that no instance of natural selection has been observed, and, we may add, that since we find arrest on every hand so that variable species are not in evidence, environments are stable, that is, favorable, and the in-

fluence of natural selection is without opportunity for its exercise. An increasing number of biologists therefore, insist that natural selection does not select and that if it has any influence it can only assist to fix an already adapted type.

But regressive or degenerative variation is not a greater difficulty of natural selection than the sterility of first-crosses, hybrids and species which cannot be crossed. Mr. Darwin's discussion of the subject is still the verdict of zoölogy. He says, "At one time it appeared to me probable, as it has to others, that the sterility of first-crosses and hybrids might have been slowly acquired through the natural selection of slightly lessened degrees of fertility, which, like any other variation, spontaneously appeared in certain individuals of one variety when crossed with those of another variety. For it would be clearly advantageous to two varieties or incipient species, if they could be kept from blending, on the same principle that, when man is selecting at the same time two varieties, it is necessary that he should keep them separate. In the first place, it may be remarked, that species inhabiting distinct regions are often sterile when crossed; now it could clearly have been of no advantage to such separated species to have been rendered mutually sterile, and consequently this could not have

been effected through natural selection; but it may perhaps be argued, that, if a species was rendered sterile with some one compatriot, sterility with other species would follow as a necessary contingency. In the second place it is almost as much opposed to the theory of natural selection as to that of special creation, that in reciprocal cases the male element of one form should have been rendered utterly impotent on a second form, whilst at the same time the male element of the second form is enabled freely to fertilize the first form; for this peculiar state of the reproductive system could hardly have been advantageous to either species."

The only qualification of Mr. Darwin's statement of the case is that this peculiar form of sterility is not an objection to special creation, since in a state of nature these crosses and hybrids do not occur. Crosses of any kind among animal species are rare. Sterility remains a mark of species.

It appears that the invention of a character of service to a species is a difficult and delicate undertaking. The somatist at the outset confronts the particularist with a pertinent technical objection. Single characters are never found. They are intellectual abstractions. But by that objection he has put himself out of the running. If characters are not to be an-

alyzed and environment may not be, he cannot precisely judge of fitness. He cannot make good the survival of the fittest. He remains an impressionist. Even empiricism, observation without any theory, becomes impossible. The advocate of the doctrine of the formation of species by minimal changes replies that the technical objection does not hold; for if nature does not analyze the analysis of the mind is not, therefore, a fallacy; for the mind has also the power of synthesis. The somatist argument but calls attention to the sovereignty of the mind.

Nevertheless the conditions of natural selection are hard on any theory. At the outset it is admitted that under the sway of universal, natural selection no instance of the law has been observed. We are dealing with a theoretical proposition. Now the process of evolution is experimental, one success after innumerable trials. From the multitude of variations a single advantageous character is selected. To be of practical advantage that character must be coördinated and combined with others to become a member or organ. This complex natural character of practical advantage must be united with an organism. It must appear in adaptation in a living being. Progress, moreover, must be maintained on narrow footing along the edge of a precipice. Biology must

keep well away from pathology. If internal adaptation should often induce the "vicious circle" of functions, disease, with an environment of any strictness the species is doomed. Usually, and for long periods, these complex, advantageous characters must be retained inoperative, a tax upon the vitality and powers of the organism along with a horde of other useless characters, and it can finally be established only in the event of the isolation of the species and easy circumstances. But death treads upon the heels of life. When the pursuit is too persistent and close the species is wiped out. Concurrent with the selection of advantageous characters is the negative selection of the disadvantageous, the elimination of useless characters. The process assails both features and forms, both fluctuations and members. Generation and degeneration proceed side by side. All the selecting and assembling and coordinating and fixing of characters and organs must be as persistently undone or disused parts will encumber the form and arrest the species with a weight of useless machinery. The selected, combined, adapted, and fixed part, continuous with tissues, ducts, nerves,— all subordinate organic systems must be removed. The object is reversed but not the method. A process of constant vivisection is induced. It is as effective as a ligature. But it must not

provoke the morbid consequences of degeneration. Meanwhile the engine of generation must not pause nor slacken its power to advance living forms. If fertility is abated and life is not extinguished degeneration is insured. But generation must be restrained. Some infertility must be enforced. There must be some arbitrary measures by which this form is permitted to cross with that but not with the other; for without such arrangments species cannot be set apart. Fertility and sterility must be alike enforced but with nice discrimination of different degrees and on different occasions.

Natural selection, then, must choose an advantageous variation and combine it with others to form a useful character and correlate it in a structure of living tissues, ducts, nerves, glands, etc., maintain it during a period of uselessness in the presence of life and death conditions, provide a margin of safety, suspend the pressure of environment to fix the new character, impress the species with an arbitrary sterility and secure the degeneration and elimination of the once indispensable parts without inducing morbid processes. This is asking much of a process which has never been observed. Unless nature is a prophet there is no explanation of her exterminations. She does not deal equally with useless characters. Those which are to be useful at a later period are

spared. She is worse than arbitrary. She is partial. Also this pairing of generation and degeneration, fertility and sterility, useful and useless, advance and regression, always with a little makeweight of advantage in one scale, appears to be an equivocal speculation improved by an afterthought. Dr. A. G. Bell says,—"I too entertain the feeling that natural selection does not and cannot produce new species or varieties or cause modification of living organisms to come into existence. On the contrary its sole function is to prevent evolution. In its action it is destructive merely, not constructive—causing death not life; and though natural selection may cause the death of the unfit, it cannot produce the fit—far less evolve the fittest. It may permit the fit to survive by not killing them off if they are already in existence; but it does not bring them into existence or cause improvement in them after they have once appeared. We must look to other agencies for the cause of evolution."

CHAPTER III

ORGAN AND FUNCTION

The field of evolutionary difficulties enlarges as we proceed. The basis of every hypothesis and science is a general proposition without which there can be no rational association or explanation of the facts of research. Biological evolution rests upon the broad presumption that the organ must precede the function, protoplasm before life. The function cannot control the organ. Mr. Spencer clearly explains the situation, "If it be said that the arrangement of organic substances in particular forms, cannot be the ultimate cause of vital changes, which must depend upon the properties of such substances; it may be replied that, in the absence of structural arrangement the forces evolved cannot be so directed and combined as to secure that correspondence between inner and outer actions which constitute life. Again to the allegation that the vital activity of every germ whence an organism arises is obviously antecedent to the development of its structures; there is the answer that such germ

is not absolutely structureless, but consists of a mass of cells, containing a cell which differs from the rest, and initiates the developmental changes." Which explanation leaves us on the grand thoroughfare to germ-palsm speculations with eternal mystery before us. In this fashion the difficulty is announced and its application is evaded. The fact of antecedent germ structure, obviously inadequate to the functions to be produced, does not explain the origin of the functions in question. If the cell mechanism explains the function then the structure to which the function belongs was unnecessary. This is the more evident when Mr. Spencer is compelled to admit the precedence of function as follows,—"There is however one fact implying that function must be regarded as taking precedence of structure. Of the lowest rhizopods, which present no distinction of parts and nevertheless feed and grow and move about, Prof. Huxley has remarked that they exhibit life without organization."

But the discussion cannot be rested at this point. The proved precedence of function opens the door to ideal potencies and differentiated energies. Vitalist and creationist can ask nothing better. The search for a vera causa is hopeless. Each structural change connotes an inscrutable world of differentiated powers. The "average of accidents" cannot

"subserve the creature's nutrition" in the following instance. Recently a microscopist had the good fortune to witness one of the tragedies of the infinitesimal world. He saw an amoeba stalk, seize and devour a turbinia. He saw a speck of protoplasm flow across the field. It extended itself in runnels or pseudo-fingers. It surrounded the turbinia and ingested it. Without organs, eyes, members, nervous filaments or retaining membrane, a lump of animal jelly with a nucleus, spied the rotifer, approached, captured and devoured it. Here are the functions of a lobster or a crab in a bit of albumen. Here is an abundance of functions exercised by a morsel of protoplasm.

Again, the amoeba is a simple cell. The first forms of life are unicellular. The next step is the binary system, two cells united with correlative or common functions. If the organ must precede function, the union of cells must precede the correlation of their respective functions. How can the mechanical contact of two cells, one original function of which was separation from a parent cell, be transformed into vital correspondence between them after they have been provided with exclusive functions for their independent existence? Have they had a surplus of inoperative functions which come into play upon contact? How could there be anticipative functions?

Shall we imagine a preliminary combination of functions preparatory to the vital union of cells which are to be brought into mechanical contact? In that case do we not make function an independent entity and give it precedence over organism? When the relation of organ and function is put in question what rational basis for a doctrine of evolution remains? The cell comes into being by functions of separation. How it acquired that marvellous power we do not know. That function cannot be acquired by experience, by accidental division. That power of division, however it arise, must be retained for further multiplication, which function must be annulled or restrained that two cells may unite to form a binary or multicellular being. Functions are predominant in the union of cells. They control the organism. Even so they induce mental thimblerigging, "Now you see it, now you don't."

If this proposition of the hypothesis is inverted to account for the simplest organism, as a system of material causes evolution is discredited also in their growth. Some time ago the supposition that a vital principle controlled the organization of every plant and animal was repudiated because it was assumed that each being was the net result of an infinity of accidents distributed through millenniums of time. But an infinity of accidents however

distributed is still confusion. Mere multiplication of cells with primacy in none and without any plan will not produce plants, animals or machines. "Archetypal cells" are indispensable to the doctrine of material evolution; hence the Germ-Plasm speculations.

Nature's evolutionary inconsequence is illustrated in a manner contrary to that of the preponderance of function over organ in the deep sea fishes. In the black abysses, we are told, that crabs, crayfishes, star fishes and other species live upon the animal ooze yet retain their members unchanged. The disused parts are not aborted. The ocean deeps are not the lumber room of nature's experiments and mistakes. The great pressure and utter darkness have not put an end to variation. Here are monstrous forms compared with which Chimaera might boast of proportion and elegance. Eyes are enlarged, and some fishes have developed phosphorescent lamps and lures. These bizarre forms exist side by side with the unchanged outcasts of the plankton and littoral species. Here is the preponderance of organ over function, and nature has forgotten her husbandry and continues to support the disused parts. This double disregard of the relation of organ and function suggests either that nature is too inconstant to adhere to any permanent rule of action or that our speculations

have led us astray. On the one hand functions are exercised without appropriate organs and again they are pre-existent and architectural and, on the other hand, organs are maintained in full vigor and form after the function is disused. Further discussion of the subject is unnecessary under this title since about every subsequent, inquiry involves the same inversion, the precedence of functions for the adaptation of organs.

CHAPTER IV

ORGANISM AND ENVIRONMENT

The discussion of the relations of organism to environment is fertile in equivocations. According to theory species and life itself in the last analysis are modes of environment. In the words of Prof. Loeb, "Living creatures are chemical machines which possess the property of growing, nourishing and reproducing themselves automatically. No machine yet created by man possesses this fundamental property. This constitutes at the present time, an essential difference between the living machines and all our artificial machines. But nothing forbids the supposition that experimental science may succeed some day in producing living machines artificially." Yes, it is true, that there are no boundaries to supposition. The inorganic environment is to be the source and cause of life. Organisms are but more intimate and finer and more complex correlations than those of physics and chemistry. The thing environed is a part of the environment yet at variance with it. This higher correlation of physical form and mechanical force was a lucky hit after

innumerable failures. Chemical correlations sported into life, or gradually accumulated into automatic, self-maintaining centers. Much more rare and much later was the self-sustaining form which had the power of self-perpetuation. Until that higher form appeared all previous advances were vain or immortal; for until they had reproductive power they presented no opportunity for advance. The work must be done anew for each form. It is necessary, therefore, to presume that the automatic, chemical machine passed at once into a self-informed, reproductive apparatus; for there is no resting place between a chemical combination and the reproductive being. How self-adapting forms were disciplined by environment to qualify them for reproduction is beyond the range of the scientific imagination. It is worthy of remark that these descriptions of life in mechanical terms have almost the value of figures of speech and beg all questions. But the poetry of evolution is not our theme at present. This automatic power of a more highly concentrated and correlated environment being assumed the environment remains the mold of living forms. As a mold, however, it is both rigid and flexible. Some of its creatures are so strong in their internal, automatic correlations that extremes of life and death conditions are necessary to

their progress; some are so feebly correlated within that they are dispersed only under uniform conditions, and cannot adjust themselves to a change of climate; others can be transported into alien conditions where they have but the standing of sports, yet there they flourish and overcome their native, adapted competitors. Either the hypothesis is too flexible for verification or the relation of species to environment is too inconstant for rational induction.

The relations of organism to environment are second in importance only to the internal relations of organisms. We have been instructed to observe what havoc slight changes of altitude work among species. Little differences of climate are disastrous. Sometimes the correspondence between species and their habitat is almost attuned, sometimes species require two environments. The annual migration of eels, a long-standing mystery has at length been explained. Eels spawn in the ocean at a depth of 560 fathoms, beyond the reach of light and under a pressure of tons. As they make their way to the sea their skins become silvery and their eyes enlarge in preparation for the new conditions of life. It is not extravagant to say that here are two environments for the same organism. The change is from the delicate pressures of the lighted ponds to the blackness of darkness and the crystallizing compression

of the nether deeps. This same nature which makes a creature which may be frozen and thawed and put into an hydraulic press without inconvenience to the victim chases all the birds out of the land at the threat of winter, and commands the animals to bury themselves. Relatives of these same eels cannot survive in colder latitudes.

Occasionally the environment is made a long-range weapon. The crocodile takes toll of animals and men at the riverbank. His ferocity is not the measure of his malign power. The plains of central Africa are uninhabitable for horses and cattle because he lives in the waters. He infects the tse-tse fly with trypanosoma, the bacillus of sleeping sickness, which induces meningitis, and the fly infects men and animals. The eel defies the power of environment, but the presence of the crocodile in the environment makes half a continent untenable for unadapted species.

Correspondence, therefore, between organism and environment is sometimes elastic and sometimes rigid. The habit of biologists to draw a check on altitude, temperature and topography for the appearance, disappearance and every modification of species is desperate business.

Pliability of species under the influence of environment is an inconvenient assumption

when other evolutionary principles are to be verified. Species become remarkably stable when the subject is the distribution of plants and animals. The flora of the White Mountains is connected with the flora of Labrador, and that flora in turn is related to the Alpine vegetation. Since species are distributed from a single center their change of habitat has been occasioned by alternate glacial and tropical changes of climate. "Nature," says Prof. DeVries, "as far as we know, changes her standard from time to time only in consequence of the migrations of species, or of the local changes of climate." But a species of cinquefoil and one of sandwort are found in Spitzbergen, Labrador, the White Mountains and on the coast of Maine. They have been so uncompromising that they have been transported from land to land unchanged by variations of temperature and altitude. Where more moderate conditions prevail their intractable representatives take refuge in the higher ranges. The same stability which restrained them from the European lowlands drives them to the American highlands. When the question of the modification of species is in debate, species are regarded as responsive to the environment; when the topic is distribution of species they are not amenable to the influence of climate but follow the temperature from land to land and from altitude to altitude.

If their course were strewn with representatives of the same species modified to survive in lower levels, the stable and modified varieties would show the influence of climate and the higher ranges would preserve the unmodified remnant of the migration, for the good reason that these representatives of the species had not changed their conditions in the course of their migration. They always lived in a boreal climate. Without modified representatives occupying the lowlands the species must be regarded as intractable. New species arise by adaptability to environment, and they are distributed by resistance to environment. Either correspondence with environment is very inconstant or the doctrine is too flexible for verification. Survival of the fittest assumes that the environment fits.

Fitness is another name for correlation. Survival of the fittest implies a distinction between environments. The survival of the fittest will be discussed as an abstract, rational principle in another place. Here it is considered in the concrete, in application. The slow distribution of plants and animals by nature has been succeeded by the more rapid redistribution by civilization. It is a wholesale experiment. The Russian, Canadian and common thistles, clover, the sunflower, cactus, gipsy-moth, brown-tail moth, Colorado potato beetle,

innumerable fishes, English sparrow, European rabbit, red fox, bees,—the catalog is interminable. We must analyze environment as we distinguish species to enable us to judge of fitness. Temperature, altitude, topography, soil, —many elements enter into the conception of environments from continental peculiarities to the conditions of the extinct craters of Pichinca and Cotopaxi. The continents have their own flora and fauna, also territories but a few miles in diameter. The environment is the inducing cause of variation and the instrument of selection. If the correlation of species and environment is close and constant, and the variation of species is unlimited or directed by the environment the schedule of possible species should be complete and native species should have the advantage over imported forms. If fit means anything a species adapted to one environment is not adapted to another. The Colorado potato beetle fed upon the sand-burr in its restricted habitat about the head waters of the Missouri. When it appeared upon the Atlantic seaboard in 1874 it had covered the Mississippi valley and the Appalachian range. In all environments it has flourished. It has changed its food for a different species of plants and enlarged its menu. Formerly it was a species of few individuals, now it swarms everywhere. It abounds in the presence of twenty

listed enemies. It has varied somewhat in size and color but shows not acquired characteristics.

The Scotch thistle was invented and fixed by the environment of a moist, cool and fickle climate and imported into Australia. The peculiar climate of that isolated continent has a singular and consistent flora and fauna stimulated and selected by a fiercely tropical temperature. But the thistle grew to gigantic proportions and massed into impenetrable canebrakes. The Australian vegetation was extirpated before it. The environment did not fit its own species and it was full of holes. Either it was incompetent to provoke adequate variation that it might have material for the exercise of its power of selection, or having abundant variations it failed in rigorous selection. The particular adaptation of a species of praying mantis which may imitate the eccentric petals of an orchid is a fascinating subject of curiosity, but it is not as illuminating as these wholesale, world-wide experiments. What constitutes natural fitness and when does an environment fit are still subjects for urgent inquiry and research. If environment is the cause and mold of species, it should have filled its schedule of possible forms at least beyond the possibility of the successful intrusion of the creatures of a different en-

vironment. In the opinion of Mr. Wallace, the intimacy between organism and environment makes impossible the persistence of sports,—"For these large accidental variations or sports, occurring rarely, would have enormous chances against their being in exact adaptation to the whole inorganic and organic environment at the time and in the place where they happen to appear. They would thus necessarily die out." How, then, would any particular environment deal with alien species, which under the new conditions have but the standing of sports?

CHAPTER V

VARIATION AND CHANCE

Exactly what is meant by spontaneous variation? If the response of organisms to environment is direct and instant, variation is only apparently spontaneous. If the cause of variation is in the organism and due to a principle in the organism, variation is not spontaneous. If variation is due to such resident principle modified by an environment already ordered, it occurs under a double system of predetermined conditions too complex for explanation but manifestly under law. If we suppose that variation occurs at random but fulfills all the conditions presented by environment, it is spontaneous in appearance but predetermined in character. But if variations are by chance, the necessarian view of nature which is presumed in all investigations by mechanist evolutionists is repudiated. The search for a vera causa, which means an efficient, mechanical cause is suspended. Spontaneous variation, therefore, is but the convenient term of ignorance and the language of appearances.

Prof. DeVries affirms that mutation and Dar-

winism are not in necessary conflict. Mr. Wallace, in reply to Lamarckians, asserts that mutations are but extreme forms of spontaneous variation. But Darwinism is a particularist doctrine. The organism is built up by a multitude of specific, selected adaptations. While we must presume that the organism is in some degree affected by every specific adaptation, this is the opposite pole of reasoning from that of somatic variation, that is, the variation of the whole form, concomitant variation of every member and organ. Flower, seeds, leaf, stalk and root are changed as if minted and that without help of the environment. It is a generalized change. It is architectural. It has the appearance of predetermination in so far as the organism and the environment are concerned in the process. Somatic variation is not the assertion of a vital principle or organic plan only because naturalists refuse to make an obvious inference. And Mutation as a form of spontaneous variation contradicts the theory that organisms are built up by particular adaptations.

Since there can be no evolution without variation it is necessary to consider the topic more narrowly. There are two forms, spontaneous and individual. Spontaneous variation is rare, individual variation, "fluctuations" are common. Upon which does selection

fasten? Mr. Darwin, in his early works, preferred spontaneous variation, but later he inclined to the position of Mr. Wallace, to individual variation. He argued that spontaneous variation did not affect posterity. By selection, small variations, slowly effected and accumulated and intensified accomplished the change of species. Mr. F. Pechoutre points out that Quetelet's law, "which opened a new phase of biological research; the statistical study of variation and heredity" does not agree with this hypothesis. "The results of these researches show that individual variations, whether they are common, fluctuating, gradual or continuous, group themselves about a mean value, on each side of which the frequency of a given variation is inversely proportioned to its magnitude. The curve of variation obtained from a great number of observations is identical with the curve of probable error."

Concomitant variation is a principle of nature which assumes increasing importance. It was announced and illustrated when the theory of evolution was first expounded. White cats with blue eyes are deaf. If the white cat has yellow eyes he hears. A wild cat with those marks and that infirmity would be elect unto destruction. There is a trap set for him in his senses. This deafness is an arbitrary penalty. Other white animals are not dealt with so

hardly. His disability is inflicted like a rule of the game, not like a law of nature. But concomitant variation has become the law of species. Concomitant variation has advanced until it is now the mutation theory of the origin of species. All the organs of the organism are subject to a law of concordant and proportional change. The correlation of organs is indispensable to the existence of the organism. It is a higher, more delicate and later law and a problem of structure. It is guaranteed by another law, a law of heredity, that is, that specific characters are dominant over varietal characters, the older over the more recent. Of all the contrivances of nature none is more delicate and cunningly devised than eyes. In point of ingenuity they rank with the vital organs, and in point of utility they stand next in order. They are the highest sense organs of locomotor animals. They are the most general and the chief means of animal freedom, action at a distance. They range from mere pigmentation of the ectoderm to the self-adjusting stereoscopic cameras of man. But eyes are notorious transgressors of the law of concomitant variation according to the rules of vital organs. They will not conform in type, number, place or coordination with the rest of the organism. Higher organisms have eyes of a lower type and lower animals have eyes of a

more perfect structure and higher functions. They are not correlated with the locomotive powers of the mammal.

This matter of eyes illustrates a danger always impending in our efforts to explain the methods of nature. Given a general law, as this of concomitant variation, which research modifies by particular, independent variation of special organs, when further modifications are demanded by the dictates of observation, the original thesis is reduced to the merest rudiment of itself or is obliterated, and the diligent specialist is not aware of the fact that he has nothing but his prepossessions left. The thesis has been whittled away by qualification.

Concomitant variation is the supreme problem of natural selection. The effort to reduce the world of structures and infinity of functions to the terms and conditions of atomic elements has issued in the creation of an infinite number of minute, omnipotential particles or monads. The failure of these speculations is recorded in the refusal of every biologist to adopt the proposals of his peers. At the same time the subject has been canvassed upon the opposite assumption of somatic variation, the modification of the whole structure. The first method would build up the type out of the many particular variations of parts of the structure. The movement is from the simple to the complex.

Our mental constitution compels us to adopt this particularist method. Without it there is no explanation of species. The question remains, how do chance variations become orderly arrangements and organic structures? Natural selection in connection with a doctrine of chance deals only with simple variations. There are no simple variations. The somatist would obviate the necessity of tracing particular characters on the ground that they do not occur singly. They exist in combination. He feels that, because as a matter of fact, characters are presented by nature in groups, he is, therefore, under no bonds to explain her action by instances of natural selection, but only to concern himself with total results. But if natural selection is not predicated of the parts how can it be affirmed of the whole?

But if the somatist admit the impossibility of applying natural selection directly for the establishment of particular characters, still with Darwinians he must justify his reasoning in connection with the presumption of chance. Weismann (Ev. Th. p. 75) says, "This is an objection directed against the principle of selection itself, and one which points, I think, to an incompleteness in it, as it was understood by Darwin and Wallace. The same objection can be made to every adaptation of an organ through natural selection." Plate says, "—the

individual variation is indeterminate and undirected, or, better expressed, universal and all-sided," therefore, "at any given moment the exactly needed modification will always appear in a number of individuals of any species rich in individuals, provided that the needed variation can be produced through a slight advance or progressive change." This is a most remarkable doctrine. Variations are "indeterminate and all-sided," yet many are identical and simultaneous and correlated in the structure to other concomitant variations, and the reason why there are plenty of identical variations in different individuals is because variation is "indeterminate and all-sided." Indeterminatness and all-sidedness is the guarantee of similarity, conformity and repetition. The particular steps of this singular exposition of a doctrine of chance are fully as remarkable as the irrational assumption. Variation without law, chance variation, implies repetition, redundancy. The redundancy of variations under infinite chance is so great that the variations are not only repetitious but also simultaneous. Indeed simultaneous repetitions of chance variations in different individuals is so frequent that they can be trusted to advance the whole structural world of organisms. They are so abundant that there are enough of them in accidental concomitance with other variations

of the same organism to secure the correlation of variations. By chance, then, we are to expect variations indeterminate and all sided; variations which are repetitious; repetitious variations which are simultaneous; repetitious, simultaneous variations of a complex character; repetitious, simultaneous, complex variations which are correlated; for, "in infinitely many cases the needed plural variation will appear." This is why somatists need not bother about particular natural selection. The whole, complex, organic structure is the subject of natural selection. The infinite variety of chance has been considerably reduced by these necessary conditions of variation. Even so somatists are somewhat put to it and inclined to amend their plea. They claim that their critics invert the elements of the evolutionary process. It is variation which determines selection; selection does not determine variation. They consider that they should be required only to reason backward, from selection to variation. They maintain that abundant, complex variations are provided by nature. It is their duty to explain only the selection. The point of the critic is that chance cannot provide them, and the principal responsibility is shirked when this provision of variations is diregarded. How did such complex variations occur under infinite chance? Darwinians also prefer to prove their conten-

tion after the same fashion, "If a complex adaptation has arisen through selection, then it is certain that the necessary modification needed for success in the struggle for existence were not wanting." Perhaps this calm assumption of the matter in dispute is connected with that other custom of the Darwinian school, namely, that in the beginning of discussion they insist that the burden of proof belongs to the opponent.

Variation, then, is of two kinds, spontaneous and individual. Spontaneous variation is inconsistent with necessarian views of mechanist evolutionists. Because spontaneity can know no law, it cannot be rationalized. If variation arises by a principle in the organism, it is not spontaneous. If the variation is applicable in so complex a structure as an organism, the presumption is that it cannot be spontaneous. Spontaneous variation is but the language of appearances and the difference between spontaneous variation and individual variation is a difference of degree. But the two forms of variation are respectively the occasion of two schools of evolutionists. Their claims are irreconcilable. The mutationist believes in ready-made characters, the Darwinian in accumulated characters. According to Darwinism life flows, but according to the mutationist it proceeds by

leaps and bounds. Darwinism deals with particular variations; mutationism is somatic. Logical Darwinism as a primary duty must explain the adaptation of a new character to the structure itself; mutationism assumes this correlation of characters, and inclines to regard all variations as changes of the whole organism. The one assumes concomitance before the fact of variation, the other applies it after the fact. Quetelet's law, that individual variations revolve about a mean and show no tendency to accumulate in any direction is fatal to Darwinism, which also finds sports an insoluble problem. To mutationists, because variations are somatic, sports are to be expected but unaccountable; for total, inseparable results are connected with total, undifferentiated causes and conditions. Both schools assume a contradiction, namely, concomitance by chance.

CHAPTER VI

VARIATION AND HEREDITY

Mendel's law of dominant and recessive strains of the progeny of plants and animals appeared to illuminate the mysterious subject of the relations of variation and heredity. He held that there was no confusion of parental qualities in the offspring. Heredity strains were transmitted intact. Characters were neither interchanged nor blent. When experimenting with peas and guinea pigs the strains remained segregated. But Francis Galton found that certain characteristics of parents were as unmistakably blended in the children. Mulattoes, Eurasians, half-breed Indians, intermediates in color, feature and form,—familiar instances are so abundant that it seems unsportsmanlike to discuss so weighty scientific questions with these homely, common instances. These facts are not properly scientific materials, laboratory facts. They have not been taken with rod, reel and fly. But we can do better. Prof. W. E. Castle crossed rabbits with long, lop ears with a variety having short, erect ears, and obtained rabbits with

ears of intermediate length and partial lop. By a second cross of this progeny with the long- and lop-eared variety he produced a breed with three-quarters long- and lop-ears. The strains intermingled. From Prof. DeVries we have a different report. In three crosses of the variety with the parent species he found "the hybrid like the parent species and not like the variety. Nor was it intermediate." He, therefore, concluded, "Here it is proved that the older character dominates the younger one," which does not appear to be true according to the experiments of Prof. Castle. Further experiment by breeders and botanists has shown that the application of Mendel's law is not only limited with regard to the subjects to which it may apply but that also the changes which it may produce are limited and the results are not permanent. "Selection according to a constant standard soon reaches a limit which it is not capable of transgressing" is the conclusion of Prof. DeVries. But again we find that nature deals wantonly. She has different methods with different creatures.

The first disciples of Mr. Darwin felt that they could observe and expound the ways of nature with the naked eye, but now evolutionists find the ultramicroscope insufficient. Since DeVries taught that species were mu-

tant the doctrines of minimal changes and natural selection have been discredited. The pursuit of origins has swept out of the visible world. Research has been pushed off the platform of the sensible into the abyss of the imperceptible. According to Mr. J. Percy Moore, the mechanism of heredity, "a mechanism by which the segregation of characters may be brought about in exactly the proportions described," that is, proportions of different hereditary strains in the individual, "must be sought in the constitution of cells." What the present prospect of discovery of this apparatus may be we can understand when we remember that all the wealth of visible structures must be read from the molecular and chemical composition of nucleated cells. Whichever way we turn the springs and patterns of the evolutionary process are inscrutable. Should we assume a vital principle to mould and direct each formation we must Platonize. We may quote the ancient dogma, "visible beings are compounded of invisible species, plans or ideas." If we are disposed still to seek adequate causes in matter, the stupendous morphology of nature must be rendered in terms of chemistry and find its relations explained in molecular laws and conditions. Chemistry becomes a science of material transcendentalism, if we may imagine such

a paradox. On either supposition the origin and method of evolution are relegated to the regions of the mysterious, the inscrutable and the inorganic which is amply illustrated by the Germ-Plasm theories.

When simple cells almost identical to our powers of observation produce this one an elephant, that, a condor and a third, a mouse we are inclined to believe that their endowment, their potencies are miraculous and the labor of explanation which science has undertaken is an impossible task. Mr. Darwin with his marvellous ingenuity and insight addressed himself to the work of exposition of the nature and properties of cells. The cell mechanism held the secret of the evolutionary process. Without a theory of cell-structure and relations the enterprise of exposition was without a beginning. To this end he invented the hypothesis of pangenesis. After the manner of physics and chemistry, he assumed that there was a vital atom or gemmule, capable of multiplication, like its parent cell, by division, which circulated throughout the formative organism and was finally arrested by other, soma cells by some subtle attraction or affinity. Without these gemmules the structure cells remained undifferentiated. When a gemmule found an indifferent cell it entered the cell, and that cell took on the potencies of the cell

from which the gemmule was produced. The indifferent cell became a gland cell, a bone cell, or a brain cell. This gemmule of course, could not fulfill its office anywhere in the growing structure or all kinds of cells would be mixed. There must be order. It must find the indifferent cell in its proper place and structural sequence. This it did by "elective affinity," a function without an appropriate organ.

When the Morse telegraph was invented and civilization was endowed with a nervous system it was but the beginning of wonders. Marconi's invention was more marvellous, and had Pupin succeeded in his effort to attune the transmitters and receivers of his wireless telegraph to give his instruments selective power, this last invention would have done away with wires and poles and relays, the visible means of transmission. Pangenesis is a simplification of the same kind. The apparatus of visible anatomy and physiology is set aside by the assumption of a realm of different properties and finer potencies. The subject is simplified by sublimation. For observable relations we have supersensible affinities; for the mysterious qualities of known cells, we have imperceptible gemmules rehearsing the same parts of growth and multiplication and equipped with the same qualities under the laws of a supernal biology. We must endorse the remark of a discriminat-

ing biologist, himself an ardent Darwinian, "These general theories are the atomic theories of biology without one tenth the probability of truth or one tenth the actual acceptance that the atomic theory of the chemist has. And even that is beginning to be discarded in modern chemistry."

But heredity is the bastion to be stormed or the city may never surrender. DeVries lays siege to it with improved weapons. Mr. Darwin's gemmules are replaced by pangenes, with vital atoms of miscellaneous characters and habits. They also are nourished, grow and divide. They are deprived of the power of general circulation in the organism. They exist in the cell under rigid rules of behavior. Their residence and nursery is the nucleus of the cell where they remain comparatively passive. They escape from the nucleus into the surrounding cytoplasm or cell fluid at the proper time. Here they exercise their functions and impart character to the cell. Like the nucleus and within it they multiply by division that the new cell may be furnished with all kinds of pangenes. Some of them are specialized for the division of the cell in which they exist. But how these specialized cells are enabled to divide themselves is not discussed.

Instead of Mr. Darwin's general circulation of gemmules to bring them into relation with

the indifferent cells of the growing organism, we have all kinds of pangenes in every cell. Fewer varieties of associated pangenes are needed to form endless varieties of characters than dissociated gemmules on the mathematical principle that a combination of a few characteristics can be varied indefinitely.

But if all the pangenes are present and alike active the cells would be uniform in character. We see that there must be some engineers among them to divide the nucleus. We must also assume an intermittent activity for the pangenes. And the nucleus must supply some means of discrimination and control if the whole herd is not to escape into the cytoplasm and put an end to peculiarity and tendency in the cells. For the subtle affinities of Mr. Darwin's cells and gemmules we have a remarkable power of discrimination ascribed to the nucleus which cannot divide itself without the action of its contained and controlled pangenes. This hypothesis has the advantage of that of Mr. Darwin in that it requires a smaller number of vital units, but for a general circulation of gemmules and their affinities we must substitute a discreet nucleus with unlimited powers of discrimination. Prof. DeVries also would give a molecular explanation of the peculiarities of pangenes.

The foregoing hypotheses are insignificant

beside the speculations of Prof. August Weismann. It was his hand that dealt the fatal blow to the Lamarckian doctrine of the inheritance of acquired characteristics. By that act variation and adaptation lost the power to advance organic evolution. The mechanism of life must be explained anew. Mr. Darwin's initiative must be more thoroughly prosecuted. If there is no accumulation of characters by inheritance there is no evolution; if there is only random variation, tendency and result in nature are at an end; If there is definite organic form without mechanical determination of that form, evolution is not an automatic process and there is purpose in nature. He also descended into the subsensible realm and proceeded to frame a sufficient hypothesis.

In the beginning there was immortal, self-contained, unaccountable, primordial plasm. It was simple, capable of nourishment, growth and multiplication by division. By adaptation to various conditions and different chemical composition the germ elements of this plasm were endowed with an unlimited variety of characters. There were then two kinds of plasm, germ-plasm and soma-plasm, and there are three orders of vital units, biophors, determinants and ids. The biophors, "vital units of the first order," are of almost infinite variety. Their diverse characters will not combine to

form an organic structure. They cannot be consistently related. It is necessary to reduce their riotous multiplicity and to establish tendency. The biophors, therefore, are associated according to the numerical affinities of chemistry in larger groups called determinants. Determinants are, "vital units of the second order." They also are capable of nourishment, growth and multiplication by division. These aggregates numerically reduce the potent elements of cells while the characteristics of the determinants are multiplied. Since their efficiency will now depend upon the preponderance of some of these associated characters, tendency and more definite results are possible. Determinants as life-units are also subject to variation.

Many thousands of assembled determinants constitute an id, "vital unit of the third order." These ids are little globular bodies arranged in strings, the "idants" of the germ-cells. These, "vital units of the third order," also are nourished, grow and multiply by division. As the determinants secure definiteness of result and tendency by the preponderance or interaction of associated biophors, so each id has a higher internal arrangment, "architecture" than the determinants. The ids are so highly endowed that, "one id is enough for ontogeny," the development of a complete organism. The

architecture of the id is the potential plan of the organism.

If the complexity of the hypothesis has not induced vertigo, add to this scheme of wheels within wheels the principle of "amphimixia," that is, bi-parental reproduction as modifying all three orders of vital units and a multiplicity and variety of conditions have been imagined which should be available for all possible demands. It is an hypothesis of poetic range and dignity.

But now that the vital units have been partially described we must understand their operation. Invoking the principle of selection in all three realms of vital orders, overmultiplication will entail a struggle for nourishment among the biophors, determinants and ids respectively with the consequent destruction of the weaker and poorly nourished individuals. Each vital unit is, therefore, not only different from its fellows but it is also subject to continuous variation, adaptation and selection.

In the formation of an organism it is these germ-cells which contain the idants which contain the ids which contain the determinants which contain the biophors which constitute the germ-plasm which give character and potency to the other, indifferent, soma-cells which are formed in ontogeny, the process of repro-

ducing the individual organism. These germ-cells are microcosms of morphology.

Mr. Darwin placed the right gemmule in the right cell at the right moment by universal circulation and subtle attractions, and Prof. De-Vries on the contrary put all kinds of pangenes in the nucleus and allowed only those pangenes to escape into the surrounding fluid of the cell which were appropriate. But the more ingenious germ cells of Prof. Weismann divide and their ids, determinants and biophors divide along with them. Each half, therefore, of the cell will contain all varieties of ids, determinants and biophors which were in the parent cell. While the indifferent cells of the new organism multiply the germ-cells are multiplying along with them.

Now the reverse of the process of integration of biophors into determinants and determinants into ids takes place while the organism is forming. The disintegration of the ids releases the determinants to the indifferent cells until by subdivision there is an appropriate determinant for the nucleus of every cell or group of cells of the organism. As the organic cells multiply the contents of the germ-cells are reduced and distributed. The determinant now lodged in the nucleus of the indifferent cell undergoes disintegration and its constituent biophors are released and escape into the outer

cell fluid. In this manner the remotest cell of the organism is supplied, with tendency and potency.

The placing of these character-bearing units in the right place at the right time is as great a problem as their invention. To this end an additional hypothesis has been worked out to determine the necessary course by which striped-muscle biophors shall find their way to striped-muscle positions among the cells and empower them with the functions of involuntary muscles.

But the exposition of the Germ-Plasm Theory is not yet complete. Recalling the fact that the hypothesis was proposed to supply the defect of a doctrine of the accumulation by inheritance of acquired characteristics for the advance of the evolutionary process we may survey the extent of terriotry covered by assumption from a different eminence;—

The house is drawn too large for the lot in one of its dimensions. It is not correct to say that these vital elements are formed after the analogy of chemical compounds. They are also chemical compounds. The biophors are of infinite diversity, and they are diverse because they are composed of various molecules. They differ not because of vital experience but because of their differing chemical composition. The speculation crosses the line between the or-

ganic and the inorganic, although Prof. Weismann adopts the statement of DeVries that it is impossible to approach the problem of the origin of life. These biophors, "vital units of the first order" face both ways. They are chemically diversified to combine vitally into determinants, "vital units of the second order."

Two species of cells are formed by the same chemistry; one species, the neutral, structure cells, have but the power to grow, nourish and multiply. Other characters are denied them although they too are composed of different molecules. The germ-cells, formed under the same conditions and laws, are infinitely various. It is an instructed and disciplined chemistry which furnishes such convenient results.

At this point there is needed yet another hypothesis. The determinants "vital units of the second order" are composed of biophors. The determinants as vital units grow, are nourishd and multiply, that is, they divide, like true cells, into two parts (binary division). Now to cut in two all the apples in a barrel is not to divide a barrel of apples. All the operations of cells are internal. There must be some specialized cells to accomplish this function. The division of biophors will not divide the determinant in which they are included and organized. The inheritance of acquired characteristics is repudiated. For that special pur-

pose the germ-plasm hypothesis was invented. Therefore, from the beginning there was a third variety of cells which were incorporated in the determinants as biophors to secure this division of the determinants.

But the biophors also divide. To reverse a figure, the division of a barrel of apples does not divide the apples. These complex biophors must also contain cells or molecules specialized to perform this important operation. And these constituents, in turn, must be complex and must be provided with the elements to secure their division. Here are powers in perpetual entail. Here is a regression into infinity of subordinate organic or chemical apparatus. It is the infinite repetition of the images of an object between opposed mirrors. And here is a new law of chemical action, division in half of a molecular combination. Anyone who is informed upon the subject of the electrical disruption of elements and atoms will appreciate the boldness of this implication of the doctrine of the division of chemical units.

How has it come to pass that the biophors of the germ-plasm are all united into determinants? Originally this could not have been the case. It is a large presumption that free biophors unanimously united into determinants. But they all must unite or the independent biophors will have no conscience about union with

structure cells in advance of their organized brethren and develop a monstrosity of excrescences. An edict of proscription, a Russian ukase of extermination, is necessary to maintain the integrity of the formative organism. Also within the determinants, the organized biophors must divide unanimously, or when they are distributed in the structure which they are building there will be strays, in all conditions of immaturity, to sow the organism with their unlawful and intractable progeny. Again, ids are aggregates of determinants. They are, "life units of the third order." We have seen that sporadic, independent biophors must perish by royal proscription or they will defeat the organic structure by sowing it with their unhallowed progeny, also they must multiply unanimously or their irregular offspring must be massacred to preserve the social order of the determinants. They also must provide the determinants with the power of division and again we are between mystery and an infinity of abstraction,

The ids in like manner must rehearse the same parts under the same conditions. Sporadic determinants and determinants of irregular multiplication must be suppressed. It is reasoning of this kind which tempts people to suspect natural science of speculative tendencies.

Now all these squads, companies and regiments which move in battalion drill are subject to a law of variation, particularly and in all combinations. The simplification obtained by higher and higher combinations of vital units at the same time represents a boiling multiplicity. As an hypothesis of cloud-formation the Germ-Plasm Theory might obtain grave consideration but as an account of organic structure it stands in some need of verification.

But this exposition of the Germ-Plasm Theory is still incomplete, and, on the word of its author, as the hypothesis left his hands, it was incomplete. At every point still other supporting hypotheses are needed. Biophors, determinants and ids have unknown powers and attractions and repulsions and affinities and potencies which determine their constitution, connections and history, for which no mechanism can be assigned. But as it is designed, the student who understands it is amply prepared for the instructions of the Mahatmas and a course in astral physics.

Not all scientists are convinced of the truth of the germ-plasm doctrines. Experimenters as a class do not adopt the Weismann form of the hypothesis. They argue that in the distribution of the germ-plasm elements—biophors, determinants and ids,—it is assumed that division and subdivision of the determinants

goes forward according to their characters, while the only known division of simple cells is binary, a mechanical, single division into two cells. They point out that in the higher plants their tissues have the power of reproduction. Lower animals restore lost parts and members. Lower plants and animals bud anywhere. Grafting can proceed indefinitely. Tissues implanted from one part of an organism fulfill the functions of their new position. From these and many more facts they conclude that the germinal substance of all cells is identical and that in addition to the perceived microscopical organism of the cell there are latent characters peculiar to the species, with which the cell is endowed and for which there is no particular mechanism. Latent characters? Another metaphysical proposition! Again the determining factors of heredity are ascribed to a world of pure functions.

The ground plan of this germ-plasm theory is drawn according to another and alien realm of science, according to chemistry, and the speculations of physicists concerning the atomic constitution of matter. In part it is a chemical hypothesis. The assumption of indifferent cells which are produced under the same conditions of life as the character-bearing, germ-cells is a challenge to the hypothesis at every step of assumption; for the indifferent cells are

denied the properties of variation, adaptation and inheritance. They are forever reproduced in fixed neutrality in spite of environment, unmoved by any influence, the one stable vital form in a world of force and chance. They contradict every assumption of evolution. They become necessary the moment germ-cells are expounded and must be assumed to explain the office of their susceptible brethren, but they exist only under conditions declared to be impossible when germ-cells were invented and when the germ-plasm doctrine has been completed it is necessary to revoke all statements of evolution as a necessary process to find occasion for marvellously differentiated germ-cells; this doctrine is not equivocal; it is self-contradictory.

How the biophors empower indifferent cells and impart functions is a question as important as any operation for which an explanation is proposed. The selection of ids, determinants and biophors by a struggle for existence is a menace to established germ-tracks and functions. The result of that constant, internal struggle insures derangement and deformity of the growing structure. How can ids retain their integrity with a struggle and consequent destruction of the determinants which compose them? and how can the determinants maintain their character and potency with an

internal war of biophors? The boast of science is that she deals with facts, but what metaphysician is there who does not envy her the liberty which she takes with facts? Hypothesis is called in to support hypothesis and yet others are wanted, while function under the names of attraction, repulsion, affinity, potency and "unknown factors" outruns every device for its exposition. We would explain functions by organs and find ourselves explaining organs by their functions. But the principal service of the exhibition of these few out of a large number of germ hypotheses is to enable us to realize the magnitude of the disaster which has befallen evolutionary science by the discovery of the fact that acquired characteristics cannot be inherited, and the art and ingenuity expended that the benefits of the doctrine may be secured by the assumption of microcosm within microcosm, so that random variations of many life-units may be reduced and assembled and paired or cancelled that residual characters may institute tendency and create definite result. For this purpose entities are hypothecated that properties may be established. But all the assumptions of gemmules, pangenes, biophors and determinants are no more adventurous than the idea of indifferent cells. Here also the hypothesis abandons the field of science for the realm of metaphysics. The indifferent

cell, the functional blank, is an abstraction. It resembles mathematical points and lines. They are concepts. They are not realities, and the nuclei of the germ cells have become the monads of Leibnitzian philosophy. And they are developed side by side with soma-cells which never felt the influence of an environment, as empty and characterless as germ-cells are infinitely potent.

Among the early reformers of the Germ-Plasm Theory was its great inventor. He was aware that he had created more difficulties than he had explained. He had assumed two kinds of vital plasm, the one simplified to the point of metaphysical abstraction, the other replete with a multitude of potencies, microcosms, which are also metaphysical abstractions. As he simplified in one direction he complicated in another. He placed the same gulf between germ- and soma-cells which exists between the queen and the workers of the ant hill. One has all the experience, the other all the heredity; one has correspondence with environment, the other is isolated and inactive. The adaptive influence of life affects the worker while the drone and the queen are mere reproductive conveniences without genetic intercourse with the qualified members of the community. Neither the undifferentiated cells nor the germ-cells which impart character have access to the treasure

of heredity. A portion of the germ-plasm is always set aside by division and passes on to other organisms in a cell nucleus safe from organic detour or modification by the organism in correspondence with the environment. Germ plasm is a subterranean stream which never issues to the light and air of biological experience. Cell-plasm cannot approach germ-plasm and germ-plasm has no relation to adaptation. For the inheritance of acquired characteristics which Prof. Weismann had slain in the observed field of science he proposed an accumulation of relatively simple entities into complex entities that he might correlate or eliminate multiple tendencies. At every step the course of explanation was embarrassed by other and finer functions as affinity, potentiality, latency and "unknown factors." By the process of exposition of cellular biology the scientist was unintentionally demonstrating the increasing preponderance of function over all the organic apparatus which could be observed or imagined. Exploiting the mechanism of life, by a new road he was heading for philosophic realism which he was under bonds to avoid. He was discovering facts and acquiring habits of reasoning which were preparing for a revolution in evolutionary thought and research. One of the revenges of time and scientific Naturalism is this that the Germ-Plasm Theory should be

succeeded by the Mnemic or memory theory of organic functions.

These elaborate hypotheses are not proposed in mere wantonness and speculative enthusiasm. The facts of biology are perplexing. Each attempted explanation but discloses other and more subtle functions. The understanding is swamped by the facts and relations of living forms. The naturalist is at last driven to regard function as something different from any form of mechanical energy. Physiological-psychology had already set the example and provided the art of reducing mental qualities to physiological functions. It is a direct application of the same principle to regard all organic functions as rudimentary mental states. Mechanical or organic repetition implies a connection between two vital events. Something of the first state must remain over to induce or control the second repeated state of the organism, and the second act is a functional reminiscence of the first. Organic rhythm is, therefore, a memoriter function; hence the name of the hypothesis, The Mnemic Theory of heredity.

The first step of inquiry is into the outer darkness. We know that there are innumerable reflexes in organisms, but we do not know what they are. Touch the sole of the foot and the whole leg responds with a jerk, pull the

trigger and you discharge the gun. Let us amend the last illustration with an improved weapon, an automatic rifle. The pull discharges and reloads the gun. The next jolt or jar disturbs the trigger and the cycle of functions is repeated. The pull, the stimulus, we know, the gun is a mystery and the discharge is an avalanche of functions in response to the simple pull. It was only a question of time and discouragement until the organic unit, gemmule, pangene, biophor—should be replaced by a functional unit in explanation of the facts of heredity.

Other hypotheses import their presumptions from below. Cells are to be explained as vital molecules. With greater audacity the Mnemic hypothesis imports its principles and precedents from above. The functions of organism are employed to explain the potentialities of cells. The unit of the hypothesis is the engram.

An engram is a residual effect. Imagine a cell without experience and without acquired characters. It is vital, that is, highly complex, a very large and important assumption. The first stimulus which it receives provokes a multiple reaction; because the cell is already highly endowed, because it is a cell. But the mechanical stimulus does not functionally exhaust its power, or the cell-functions are left

in a state of poise or tension which is still the impress of the stimulus. Another vagrant stimulus arrives and there is another multiple reaction; but this second reaction, whatever the character of the stimulus, is rendered according to the precedent of the previous operation. These engrams, residual charges, after-effects, are the causes of this recurrence; hence, of organic repetition. They multiply and produce rhythm, and coalesce and form organic habits.

The engrams are stored in the nucleus of the cell, or, more particularly, in the chromatin of the nucleus. Each nucleus is the ample storehouse of the epitomized potentialities of the organism and of the race. It is a microcosm of potentialities, a functional monad. Every cell is sensitive to all organic changes and retentive of all organic affections. This perfect internal correspondence of the organism, as remarkable as the functions to be stored, is maintained by a transcendental telegraphy or, more accurately named, by a kind of telepathy. The engrams are capable of treasuring both particular functions and total functions, that is, the functioning of the organism and of the race considered as a whole. Illustration of the characteristics of cells is found in the nervous system, which is itself made up of cells the functions of which are to be explained by these

hypothetical engrams. It is not surprising that the engrams as explained by nerve-function should explain the functions of nerves. Now that the experiences of the entire organism affect every cell and are epitomized and retained as potentialities in every nucleus it is easy to see how acquired characteristics are inherited. Indeed it is difficult to see how any characteristics are not inherited. This is the sacramental theory of churchmen applied to biology. In the Germ-Plasm Theory part of the yeast is set aside for future bakings, and the part applied in the dough which is raised and kneaded and put into the oven is separated forever. In strict logic the relation of organism to environment is a relation after the fact, after the character of the organism has been determined, concomitance rather than correspondence. Cell-environment, the field of cell-discipline, is a world apart from the environment of the organism. But the Mnemic Theory with its doctrine of the universal susceptibility of the cell, its stimulus with an iron stamp, its burglar proof nucleus controlled by telepathy, a function of functions, unites all life and experience into one body of organic reminiscences. In a single nucleus is epitomized and idealized the entire ontogeny (growth of individual) and phylogeny (development of species) of species.

Not yet are the possibilities of engrams exhausted. The engram must partake of the nature of the stimulus while it exists as a state of the cell. It is suspended action, potentiality of function. How is it the occasion of repetition and, how does it become the means of organic habit? When stimuli occur in regular order, their engrams are associated in a corresponding sequence. When the stimuli become irregular or some are dropped out of the series, the sequence of engrams continues by the influence of their previous association; the relation of engrams continues after dissociation of their stimuli. The stimulus ceases to be a middled term, so that, although only the initial stimulus remain, the complete sequence of functions is rehearsed. It requires but little imagination to apply this pregnant suggestion to the whole range of life by the neglect of stimuli and the accumulation of engrams with their concurrent functions. Ontogeny, reproduction, becomes organic habit. Although it can occur but once for each life and this individual experience remains singular for the individual, it is repeated for the race, since all stimuli affect all nuclei which inherit the totality of engrams which are relevant to all previous organic experience. The individual is but a beat of the universal pulse. Life is rhythm and organism is reminiscence.

If the soma-cells of the Germ-Plasm Theory resemble abstractions, engrams are pure conceptions of the understanding. The illustrations employed explain a concept but they do not verify or explain a fact. The discharge of a gun, the education of a trick-dog, the habits of infusoria the half-conscious turn of a man at the end of a favorite stroll, the formation of apetalous flowers are far away from the point to be established, and are chosen with indiscriminate freedom from the whole range of experience, and with indifference to any organic or functional connection with the matter in dispute. One of the most eminent naturalists and an advocate of the Mnemic doctrine says, "But I shall hardly wonder if a majority of my hearers decide that the available evidence in its favor is both weak and fantastic." With the corpuscle of the physicist and chemist transformed into a center of force, and this engram of pure potentiality in biology, and a school of idealist philosophers waiting for the word, this is pessimism.

Between these hypotheses evolution is in an equivocal position. One inquires after a functional unit, the other, after an organic unit. One is ballooning in idealism, and endeavoring to get back to firm ground of organism; the other is catching at material facts to prevent being whirled away into the firmament of po-

tentialities. The Germ-Plasm Theory puts a great gulf between germ-plasm and soma-plasm. This distinction is made from observed differences between germ- and structure-cells. The chromosomes of the germ-cells are the repositories of heredity and, therefore, of organic structure. After our elaborate theorizing about the right germ-element in the right place at the right time, nature advises a reconsideration of the distinction of the two kinds of cells. She has a great number of creatures which can extemporize amputated members. Where the art and power were obtained is matter for further reflection. There must be proper germ-elements and to spare where the missing member is formed. They must be of all kinds to qualify the many parts of the missing leg or claw. One teacher supposes that there must be a network of germinal substance continuous throughout the organism. Others suppose that there are residual germs stored at the point of rupture but unused. It is perhaps a fallacy to reason from vegetal and animal cells indifferently; but since it is the custom let us follow it. By budding, with no opportunity of renewal of the necessary germ-plasm, plants are infinitely multiplied. The structure of infinitely multiplied soma-cells goes right on perpetually without any recharge of germ-plasm. What material expedient will serve to ration-

alize this fact?—if inheritance is confined to the germ-cells? Again we encounter in a new form the fact of the predominance of function over organism, that is, by perpetual entail.

If the infinite extension of unrenewed germ-plasm which, according to theory is necessary to explain the multiplication of plants by budding, has not demonstrated the absurdity of these speculations of biologists, an experiment has shown that there is no particular disposition of germ-plasm in the formation of organs and members and that there is a reserve power of plan and structure in the organism which is not localized at the point and with the tissues of which the member is formed. A rough sketch of the development of the elements of the mammal structure will explain the significance of the experiment. In general the animal body is made up of three classes of related structures connected in development: 1. The nervous system, cuticle, etc. 2. Skin proper, voluntary muscles, skeleton and muscles of the viscera, heart, large blood vessels, vascular glands, etc. 3. Lining membranes of the alimentary canal, air passages and cellular parts of internal glands. These structures are thus associated because they have a common origin in the process of reproduction. They are developed from respective layers of the blastoderm, that is, of the fold of the containing membrane of the fer-

tilized ovum in which the embryo is formed. These three layers are named, the ectoderm or epiblast, the mesoderm or mesoblast and the endoderm or hypoblast. Sense organs, however, are hybrid structures. They are compounded from elements derived from different families of structures. The art and materials for making lenses belong to the ectoderm department, and the vitreous humor, the socket of the lens, is prepared in the mesoderm department. It is evident that eyes are a later, a higher correlation of structures and a coördination across a wider gulf between structures than the vital organs of the animal. Now if the lens of the eye of a salamander tadpole be cut out, an instrument which only the ectoderm department is authorized to supply, the lens is reproduced from the optic cup, a structure which another department has produced. The new lens is made from different material by another structure. It was never given the optic cup to make lenses before the dissector employed his knife. The lens was restored without appeal to the ectoderm, from a source not qualified for the task by selection or inheritance. Biologically speaking here is a bridge extemporized across one of the widest gulfs of animal structure. Not only are germ-theories refuted but biological precedent, without which there can be no evolution, is called in question.

A twofold difficulty arises from the attempt to find a substitute for the Lamarckian doctrine of the inheritance of acquired characteristics. Creatures of the sensible world are to be explained, but their origin cannot be understood by observation. A hypothetical, inscrutable world must be presumed to account for these visible forms. The aggregation of orders of imaginary life units into structures is but part of the problem. Biophors, gemmules, pangenes, bioblasts, micellae—what not? are adapted and associated in an appropriate environment under conditions as remote from the known environment as the life-units are from visible structures. The invisible environment, therefore, must be in close correspondence with the environment of visible forms. As the life-units are potential organisms, their environment must also anticipate the conditions of the visible world. There must be a high order of unity throughout nature. Environment becomes a kind of structure over against the living forms which it contains, or the developed form would find itself in an alien world, where reformation not adaptation would be necessary. Starting then from the visible world and its observed forms, we proceed into the infinitudes for a theory of causes and beginnings. There we figure a rigorous infinitesimal environment, and prepare a creature

by that discipline to maintain itself under the conditions of the actual, observable world. The persistent correspondence of the organism with environment under conditions so diverse is scarcely more wonderful than the perfect correlation of the infinitesimal and sensible environment. The correlation of the members and organs of living structures is inferior only to the complete correspondence of the environment of nature as a whole. Environment is almost a lower form of organism.

All which theorizing but serves to drive biologists back to the doctrine of the inheritance of acquired characteristics. The last resource is somatic inheritance. However the germ-plasm appears to be shut up from direct experience of the environment, kept in safe-deposit, we must assume that it is yet so intimately connected with all parts and functions of the organism that by some photo-plastic power the hereditary deposit is remodelled by the changes and experiences of the adult form in which it is contained. Weismann isolated the germ-plasm from experience but the somatist connects it indirectly with all the forces of the environment. The Germ-Plasm Theory would introduce into the world of sense a being already prepared in the infinitesimal world, the Somatic Theory would apply the power of the sensible world to the germ-

plasm. These are equivocal suppositions and they have equal cogency.

We may conclude the discussion of germ theories with a survey of some of the more important features of these speculations. All are theories about the inscrutable. They begin beyond the range of observation. They deal with abstractions and their fundamental distinctions which are founded upon facts, like the soma-cells which build up the organism, also are abstractions. But the regeneration of lost members contradicts the assumption of the absolute difference between germ- and soma-cells. Nuclei become monads, organic microcosms. The division of cells is figured in a way which involves an infinite series of identical operations for the division and subdivision of cells. Structures which never formed a lens extemporize it by original resident powers. Each function investigated raises a swarm more varied and subtle before which speculation faints. In the multiplication of plants by budding germ-plasm becomes infinitely potential. In these many ways the predominance of function over organism is assumed. In defiance of the resolution of scientists to hold fast to naturalism, by research and speculation they are driven into philosophical Realism. Function becomes entity instead of relation and takes precedence over organism.

CHAPTER VII

REPRODUCTION AND THE GENETIC BOND

Before the discussion of reproduction let us refresh our memory with regard to the reasons by which so many people have been persuaded of the truth of evolutionary doctrines. Biologists may be never so speculative and their proposals may be illogical or futile, but errors and misadventures, while they may discredit teachers, do not destroy the meaning and force of the main thesis, the genetic connection and advance of all life by a process of gradual evolution or annul the indications of observed facts. Must we wait until the last plant or animal has been found and investigated before we may pronounce upon the truth of the general hypothesis? We perceive degrees of resemblance and analogies between kingdoms orders genera and species throughout the animate world. We find a generalized type of structure which usually simplifies backward and specializes forward in time. Linear advance is attended with collateral relations and analogies. The organic world is woven into one genetic

web. Although the beginning of life may remain a mystery and all species appear to be under arrest, from our little handbreath of historical existence as a race, shall we conclude that there has been the same paralysis in the past in defiance of both serial and collateral resemblances and analogies? There are great gulfs between genera and orders but the fortunes of geology prepare us to expect just such gaps in our schedule of species. What new form has been discovered, what extinct form exhumed which cannot be placed in our genetic scheme of structural analogies? Progressive, regressive, collateral and fluctuating movements are parts of the grand body of evidence that nature operates without tutelage and design. When, therefore, we find a clear linear series of forms in the development of the horse or the camel and similar if less complete sequences in other fortunate fields of research and exploration have we not a working model of the process of the formation of all species? When some of our typical species are found to be but a collection of "elementary species" have we not another and more precise illustration of the same process and another step for the construction of the Grand Argument and can we not see that here are species upon the point of wider divergence? Is not this narrower relationship with smaller specializations

a working-model of the wider divergence and an illustration of the way in which the greater gaps between genera and orders occurred? Must science forego her hope of a connected understanding of nature with these facts to indicate the way because life is still a mystery, because its origin and arrest are still unexplained, because there are more gaps than sequences in our schedule of living forms and because our efforts to theorize a plainly difficult and immense body of facts are defeated? When we are reminded of the fact that not an organ or muscle of man is wanting in the gorilla, when innumerable vestigeal parts which we may regard as overlapping structures in the process of advance from type to type, foot notes and marginal references of the organic procedure, and when we find the cold-blooded crawling elongated, fourfooted reptile with its sequent picket fence skeleton connected with the warm-blooded, flying foreshortened, two-footed bird with its compressed and welded thorax and pelvis by the archeopteryx with its feathered tail and toothed bill who can have the hardihood or stupidity still to doubt that these resemblances and analogies indicate one organic sequence throughout the animate world where much of chance must befall both theories and beings?

The force of this argument has crushed the

opposition of keen, cautious and reluctant minds. But it is impossible to rest with the conclusion. If there is force in the reasoning other inferences follow in stricter logic and with the weight of universal observation. All characters and powers and the form of the adult structure are withdrawn from the environment, and transformed and condensed and deposited in a microörganism. The developed form is epitomized for reproduction. The transformation is more ingenious than the life of the plant or mammal. The process of reduction and reformation is an organic process. There must be a structure to accompany and contain and effect the reproduction. It must at every moment be the immediate and sufficient cause of the transformation. It is a sufficient cause in a degree which the adult form cannot be; for the new creature is withdrawn from the environment of the developed form. These are necessary and stricter conditions of organic operation than the observed conditions of life. The organism is the condenser and the precious product must be in safe-deposit. Potencies so momentous in consequence and tremendous in their range and delicate in their nature, when applied and extended in the multitude of animal forms of the visible world, cannot be subjected to the fortunes of gross and completed individuals, a very different environment. The

accumulated tendencies of millenniums of aggregated changes and the quintessence of infinities of biological usage and precedent are not adapted to endure the shocks and strains of the open theatre of the environment of adult beings or the crude modelling of direct experience in a world of life and death emergencies. Potencies and patterns are not to be manipulated by the clumsy impact of the forces which control and modify the developed form; for if the germinal structure is fitted for the trial and chances of mature forms all previous reasoning about organism and environment is a demonstrated fallacy.

The germinal organism is, moreover, a resultant. It cannot have a life history of its own. It cannot assume the rôle of the causative, the anticipative, the prophetic; for the millenniums of habit, usage, experience, adjustment and economy in nature as extended in space and time, that is, in environment are misspent when the whole process can be short-circuited through embryology. This immediate change would demonstrate the irrelevance and futility of the inquiry into the forms and cells of living beings with regard to their origin. When evolution relegates the causes of morphology to the infinitesimal or potential realm of nature, if generative potencies can be adapted among themselves and directly controlled we have

further and final argument for the doctrine that the experience of formed beings and species are not the necessary discipline of heredity.

All structural changes must be mediated by generation. Structural sequence between the mature form and its germinal representative is the genetic thread. There are five reasons why there may not be a direct structural sequence between form and form:—

1. The seed has an independent history.

2. The mammal is not preformed in the egg.

3. Metamorphosis dispenses with generation.

4. By generation the reproductive germ is supplanted.

5. By generation the reproductive powers are suppressed.

1. The seed has a history independent of that of the plant and of its relation to the plant. Weismann argues: "It is impossible that a portion of the body should exhibit an independent variation capable of transmission unless it were represented in the germ-plasm by a special particle." What, then, must be the effect on the body of an independent variation of the seed?

On any theory the relation of seed to its plant or animal and of plant or animal to its seed should be a continuous process. If at

either point when the seed becomes a plant, or the plant produces seed the process is interrupted every theory of nature falls apart. There is no structural continuity. Resemblances between form and form become irrelevant to the question of origins. If the seed and the adult form may be independently modified a rational account of a genetic sequence in nature is impossible. If the seed by substance is continuous with the plant yet is not structurally bound by its organic laws we have the closest connection in nature and the nexus and epitome of all other biological relations a sequence of material and a disjunction of organism, sequence without correlation. The seed considered as the mechanism of heredity could not explain the fact of heredity because its organism would not be in constant relation with the adult organism of which it was supposed to hold the pattern. From a monograph by Prof. Oliver, The Seed a Chapter in Evolution, we learn that the seed itself is mutant. "Everyone of the stages emphasized involves the conception of something more abrupt than mere gradual variation. And there is the old difficulty confronting us as to how the organ or mechanism came to be preserved at its inception. All these difficulties vanish when it is recognized that effective variation is of the discontinuous order, and that the successive

changes involved may be considerable enough to be designated jumps." "Not the least of the advantages which follow in the wake of the Mutation Theory is the shortening of the time for the evolutionary process." So then the seed also is mutant; the seed jumps. What is the effect of these organic jumps upon the matured plant?

"We know now that the Lyginonodendreae and Medulloseae bore seeds attached to their fronds. The seeds have been found in some cases attached to reduced fronds consisting of a branching rachis, in others to fronds of the normal filicinean (fern) type. Indeed so far as habit is concerned these plants may rightly be described as seed-bearing ferns.

As such indeed, most people will be content to regard them,—as forms, that is, having close filicinean relationship in which the reproductive method has been profoundly modified, the internal anatomy to a less extent and the habit hardly at all." That is, spores have been remodelled into seeds without corresponding change of the plant. The relation of seed to plant is out of joint.

2. The mammal is not preformed in the egg.

Spores, then, have been changed into seeds by leaps. They also are sports. There is no opportunity to rationalize this process. The resting embryo of the seed is the rudimentary

plant. But what relation does the egg sustain to the mammal? Does the simple cell contain the rudiment of the developed form? Once it was maintained that the animal was produced from the egg by direct growth. There was a minute effigy of the animal in the egg. When that supposition was disproved, it was presumed that there was nevertheless a predisposition of the contents of the egg with reference to the parts of the animal to be produced, that is, that there was a predisposition of the substance of the egg appropriate to the members of the animal form. There was, then, some differentiation of the apparently simple substance of the egg, some preparatory organization according to the type. To test the supposition the eggs of frogs, salamanders and other species were divided and hatched. In the case of snails, it was found that a division of the egg divided the creature and the snail hatched in fragments; but division of the eggs of frogs and salamanders multiplied the frogs and salamanders. The knife was not invented which could divide them in the egg. We cannot regard these contrary results as illuminating the subject of origins. Another experiment shows that there is no organic preformation in the eggs of some species. Frogs eggs have been put into a centrefuge and spun till the contents of the egg have been separated and

rearranged by specific gravity, yet these eggs hatched not a kind of animated hash or protoplasm but misshapen yet recognizable tadpoles. These are high-handed measures with the egg, the genetic link between form and form. The existence of any cell-mechanism or preformation or predisposition of substance as a formative cause of the mammal vanishes and we are left with only ideal potencies. There is no reconciling the embryology of snails and frogs. These contrary results do not illustrate the doctrine of the uniformity of natural law. The more thorough our experiments the more mysterious is the subject.

3. Metamorphosis dispenses with generation.

On any theory of evolution modification of species is dependent upon generation. But does nature justify the doctrine? The caterpillar is an annelid, a worm, in good standing. He has only an alimentary canal with a double nerve filament beaded with ganglia stretched through him. Without a genetic act he leaps over species, families and orders and appears as a butterfly, a fluttering tulip. His organs change along with his new husk and members. There is nothing stationary, nothing left as the center and means of the change except a few minute plates. It is altogether and complete as a dissovling view. The caterpillar is recast from his alimentary canal to the scales

on his burning wings. Millenniums of biological changes are telescoped into a single moment, and innumerable genetic acts are cancelled. What has become of structural sequences in this amazing transformation? What of the formula from egg to form and from form to egg? What of a micro-organism to epitomize and recreate the mature being? The genetic circuit is abolished by impatient nature.

It is absurd to suppose that a parent form can have subsequent connection with its advanced progeny and the later structural forms become united with representatives of the earlier forms. But the preservation of the earlier form as a worm, while the insect also enters upon another state of existence is an appeal to metaphysics, transfers the genetic bond into a world of potencies and is only less difficult than a doctrine of the union of two developed insect forms.

All larvae were once annelids, true worms, and worms they remained without structural change, and in their variation the new type was annexed to the larval state. The larval state remained intact. The annelid life was lived out and the new organism ensued upon it. There was an organic pause throughout the larval period. When the change came, by the evidence of all the annelid world, it began with-

out organic precedent. It must begin by invisible potencies. It is a change inaugurated in a mystical, transcendental realm. The genetic bond has become metaphysical. It has been lifted above organic precedent and it has become a pure concept of the understanding.

In the shell-fishes the change is accomplished by a number of moults. Each moult, together with others which have been suppressed until they leave no sign of their existence, represents a state of the animal in which it went abroad, lived, fulfilled its functions and occupied a place in the world. Did nature reverse her operations and proceed to telescope these stages for insects? How, if environment is a potent force of transformation, did environment dictate the change and reverse its requirements? How did environment and the organism itself reverse the mandate and combine the whole series of forms into one grand process of transformation?

How great is the art by which these forms which once held an important place in nature are sequestered for recreation! Mr. Darwin suggested that the reproductive process was set forward as the insect developed. The insect was permitted to live out its original annelid state, but the power of reproduction was transferred to the new imago period of its life. In the seventeen-year locust (cicada) the larval

period is long. But many of these annelids develop a spinneret and transform their substance into thread and acquire the function of an automatic spindle, and wind themselves a coat impervious to wind and weather. In this artificial womb, devised by the thing which is to be its progeny, they fall into an embryonic sleep. And from this marvellous return to a formative state the creature emerges to fly, to mate, to migrate, to colonize, to build papier mache and wax nests, or equipped with spring-hung jig-saws and drills, to be the envy of the mechanical engineer,—issues from its woven womb, after a second embryonic experience, supplied with a full complement of instincts after it has lived one lease of life, after an annelid career when there was no organic anticipation or preparation as the occasion or model of its later transcendant existence.

Elsewhere nature in the development of new species, we are taught, reduces the ancestral type to a stage in the embryonic development. That is the reason assigned for an occasional toothed bill of the chick. But in metamorphosis an artificial embryonic state is induced at the end of the life-period of the original form. It is a structural supplement to that completed life. It is an organic revival. As an annelid the insect is structurally the same, but it is potentially of another order and a

different environment. The thread of connection has been carried about through a region of potencies and abstractions.

The story of the change of the pupa is worthy of rehearsal. This creature is a worm by all the marks of its anatomy. The only difference which can be detected between it and other annelids is a number of minute plates made from the layers of the membrane of its embryo. But this particular worm, with an art far above its rank, after having lived one life returns to a second embryonic state invested in an artificial womb of its own construction. Now the whole structure of the creature is destroyed to the skin. Every organ is abolished. They break up and disintegrate. In mammals there are certain cells, policemen of the circulation, which rove about and devour intruders and all lawless elements. We reinforce them when we administer antitoxin for diphtheria. They devour the swarms of malignant bacilli. When all the organs of the pupa are broken up these scavenger cells (phagocytes) fall to and devour the last vestige of the disintegrated material. There is nothing left but these minute plates (imaginal disks). Life is reduced to its lowest terms. Organization has been destroyed and the insect is a mass of elemental cells, a plasm, an animate slush, a sausage of fat.

The imaginal disks, which have been dormant in the larva for a lifetime, now come into action. They begin to develop. They take this raw animal material and make it over into the new organs of the superior creature,—new alimentary system, new nerves and ganglia, new respiratory organs. Mandibles are exchanged for a proboscis. Members for the aërial life are constructed and the whole system is connected up into one harmonious structure, utterly different from that which returned to the embryonic state in the cocoon. How fares the dispute between organ and function in this amazing process? Nature has reduced life to its lowest terms. She has taken the creature through the jaws of destruction. It is the nearest approach to a resurrection of the dead possible in biology. Function is piled up like the Alps upon the Appenines and organs are buried in the depths of the sea. In one direction we look on a world of invisible agencies,—potencies, powers and plans; in the other, looking for structures, we find a blind alley.

But the particular matter in hand, the genetic bond, bears no relation to this transformation. It is inconceivable that moths were produced from caterpillars by an act of generation, or any number of such acts. They could not be combined into one forthright organic process. Had we not observed the fact

that the states were two and that they were forms of one continuous life, caterpillars and moths would be classed not as different species but they would be set whole orders apart. Measured by Darwinian principles, metamorphosis accomplishes in an instant what by reproduction requires æons of time and innumerable generations. Without the genetic bond, without assignable organic antecedent, nature accomplishes a generic transformation. She uses the power of reproduction and she does greater marvels without it.

4. In Generation the Reproductive Germ is Supplanted.

Telegony, or persistent heredity, is another menace to the idea of a purely material genetic bond. Breeders refuse to list pure-bred females which have been fertilized by males of an impure strain. All later progeny are influenced by that first pregnancy. This is an organic tendency for which no physical cause can be assigned. Each individual is the product of one ovum, and the reproductive process begins when the spermatozoon enters it, and the process is complete when the embryo is delivered. Nothing of the germ-plasm remains to forestall the potency of the second ovum and spermatozoon which unite to produce another individual. Yet without any organic vehicle of that first heredity a colt or calf is

born with the qualities of that first sire. His influence abides although the germinal cell is different. His strain can be present only as a potency, a mysterious, incorporeal power. Function, induced function, triumphs over definite organic arrangements and structures. The genetic bond is disturbed by a metaphysical power.

Telegony is preëminently a breeder's doctrine. Evolutionists reply, first, with a blanket denial,—no facts. They say, moreover, that if there is such heredity of the first sire in the later offspring there must remain some germ-elements in the mother from the first impregnation. So strong is faith, so free is conjecture. But how does this remnant of germ-plasm obtain access to the ovum in the presence of the second spermatozoon? And, finally, in the event that this explanation may not prove satisfactory, the reproductive cells of the mother, during the first pregnancy, acquire something of the heredity of the sire. So then, in this round-about way, through the reproductive system of the female, the heredity of the first sire impresses or suspends the action of the germ-plasm of the second sire. What has become of the organic, structural sequence from parent to offspring? Either heredity has become an abstract potency affecting the reproductive powers of the mother,

or the germ-plasm of one male finds a back-door entrance to impress the germ-plasm of another with the qualities of an alien heredity. Experience also is against this supposition. The later offspring of the second sire no more resemble him than the first.

5. By generation the reproductive powers are suppressed.

By generation, generation is defeated. Every ant hill and bee hive swarms with a population in which the organs of generation are atrophied or undeveloped. The connection of these organs with the rest of the structure should be as strong as nerves and ducts and tissues could make it and as deep as life. Against the precedents of the whole animate creation nature relaxes the bond and suspends the process. How did she produce neuters? How by generation did she disable the generative powers of the great multitude of individuals who must be preserved in complete form with more highly specialized functions and which are rooted in all other organs and functions of their constitution? Straightway she selects another individual, as the queen of the termites, which is deprived of intelligence and turned into an animated womb and immovable egg factory. One is made to surrender every function but one and others must have all functions but the one. She mocks at the re-

lation of environment and heredity by placing an impassable gulf between them. The workers have all the experience and cunning, but the queen and the drones all the stupidity and heredity. Without experience the heredity is maintained by the fertile forms, and the workers which are influenced by the environment are deprived of the power to contribute to the heredity of the species. This double inconsequence nature achieved by atrophy of the generative organs. It cannot be that generation was employed to stultify itself. What nature has done as she distributes functions in the process of forming special organs she applies to the communal life of the nest and the hive. She distributes functions to specialized individuals which differ from each other more than allied species differ. She is so thorough that if the generative powers are preserved the individual is capable of nothing else, but if the individual is to retain the power of self-support the generative powers must be suppressed. Then to secure this distribution of social functions she devises an insect ingenuity more wonderful than the insect or the community. These same workers deprived of generative powers understand them so well that they apply an art and cunning by which they can meet an emergency which threatens the state, without instruction or experiment, an

art which transforms one of their kind in the larval state into a fertile individual. If this art is intelligent they are amazing entomologists and their midwifery is something miraculous. But the particular point of this transformation by insects themselves is this, the generative powers which follow upon and register and treasure the modifications of the species are themselves modified directly by the interference of the workers and that by a particular regimen and diet.

The sheet anchor of evolution is this doctrine that the resemblances, analogies and vestigeal parts of living beings constitute a system of evidences of the universal genetic relation of animate forms. Without this presumption all other arguments become irrelevant. Particular illustrations of this connection are of little importance compared with the grand spectacle of differential analogies. While it may be true that the infinite multitude and varieties of plants and animals formed under the necessary conditions and the exacting relations of vital structures if not genetically connected would also demand as complex and varying groups of associated forms, and each additional form would find a place in the general scheme according to degrees of resemblance and difference the answer would not apply to vestigeal or rudimentary parts.

Incomplete as the reply would be, it would not encounter the more serious objection that there is a critical moment for the variations and relations which the genetic view is called upon to explain. The entire morphology of the animate world must pass through the needle's eye of reproduction, a process of immediate and constant observation. Whatever impression is made by the spectacle of multiple resemblances and the classification of species it cannot be accepted as evidence of a corresponding kinship until it is verified by reproduction and justified by the genetic bond. Whether we contend for minimal changes or mutation, for natural selection alone or selection reinforced by the inheritance of acquired characteristics, all changes must be registered and transmitted by reproduction, the critical moment of evolution.

When, therefore, we conclude that the animate world is bound together by genetic laws and related according to structural resemblances we also conclude that the genetic process is constant, is the opportunity of change and that there is an inviolable structural sequence from seed to plant and from plant to seed. If this sequence is in doubt resemblances and analogies count for nothing. Observation and experiment have created that doubt. Reproduction repeats various forms as different

as species without intercourse with them or experience of their environment. By generation the sacred organs are disabled and their precious deposit of heredity is sealed up. An impassable gulf is placed between them and posterity and a wide gap of differentiation between them and the parent form. Again the disabled progeny have the art by particular care and special diet to develop and restore the immature generative organs and renew the parent form. The seed, the resultant and depository of heredity, undergoes a radical transformation on its own account without modification of the adult form. Here is material and functional sequence with organic interruption. By experiment we know that the egg also shows no necessary predisposition of material or structural precedent which shall be the law of the completed form. By metamorphosis the work of ages of generation is surpassed by a momentary, direct organic act, which is initiated by an all but complete destruction. Of what value, then are the resemblances of individuals and species as evidence of a necessary genetic bond when the relation of parent and offspring does not depend upon structural sequence. Reproduction does not entail resemblance to the parent queen or drone. The inheritance of reproductive powers and organs rooted in the constitution of

the individual does not dictate the form or structure of the seed, nor a predisposition of the contents of the egg the character of the animal. There is material and functional connection, but there is not necessary structural sequence. In the critical moment or reproduction resemblances lose their relevance as signs of kinship.

Our theories demand that every change be mediated by generation. Without it we lose the thread of connection in the world of living beings. Here if anywhere nature should be constant. But to-day she sacrifices innumerable drones as mere reproductive conveniences upon her Cyprian altar and to-morrow the individual is hedged about with protective appliances. To-day she is ritualistic and all the forms must be minutely observed. She is so concerned about her creature that her arts of reproduction must be elaborated; to-morrow the consummately devised and perfected individual has served her purpose, and he is delivered to the mob and perishes by the stings of the hive; and on the next day she is of a mind to abridge the whole process as a piece of wearisome rigmarole, and does greater marvels without regard to generation.

For both the doctrines of resemblances and evolution this is the critical moment. Organism is the subject of biological evolution.

Every speculation must take it abroad at least as ballast. No Platonist pleads the pre-existence of vital principles. Hindustan is the proper country for such idealism. Resemblances must come to the test of the genetic bond. How shall we rationalize the fact that a worm is also a butterfly? Shall we say that once upon a time there was a whole series of forms connected by many acts of reproduction, as Mr. Darwin hints but hesitates to affirm? that the annelid had once the power of reproduction because there are rare instances of the production of eggs in both larval and imago states? that the different forms of the series were telescoped as genetic acts were dropped? Can the reproductive process upon which the connection of life depends be withdrawn into the parent form and be transmuted into an internal, organic process and different organisms be blended into one? Can any creature assume a second embryonic state that a whole series of forms from crawling, rudimentary worms to complex, flying imagos may be united into one continuous organic process of self-transmutation? Can the genetic bond of higher forms (moths) be latent in a lower form (larvæ, annelids) and remain a material structural bond? And under biological laws is the reverse process also possible? Can generation which is transformed into a continuous

organic process also be set aside and species be modified and maintained by lieutenancy? by creatures who have no genetic reciprocity with the neuter form or the conditions of their existence? On the one hand, generation is to become a continuous, internal, organic process and bridge more than generic differences, and, on the other, generation is removed from the life and experience of one variety and delegated to another. These different operations are not equivocal; they are contradictory.

Again, the organic continuity from worm to fly is to be construed with the facts that seeds are independently modified and eggs disorganized and deranged without corresponding revolution of the structure of the reproduced individual. The seed may jump and the frog's egg will produce a tadpole whatever may be done to the germinal structure so long as the egg will hatch. The genetic bond as a structural fact is set aside by independent modification of the seed, the store-house and pattern of the adult form or it is destroyed without defeating the result or it is withdrawn into the organism as a continuous embryonic process of an individual, or it is let out to other individuals, or its structural power is supplanted in part at least by the heredity of a previous act of generation. These facts are as obvious and far more pertinent to the question, is all

life genetically related, than the toe of the horse, the semi-lunar fold of the human eyelid as the rudiment of a nictitating membrane or the resemblances, analogies and homologies of the comparative anatomy of apes and men. When we learn further that every organ, membrane, duct, blood vessel, tendon and muscle of the African elephant exists in the shrew mouse the value of organic resemblances between men and apes is discounted.

CHAPTER VIII

REPRODUCTION AND REMINISCENCE

Prof. Haeckel saw in ontogeny, reproduction of the individual, an epitome of phylogeny, the development of species. In Landois and Stirling's Physiology we read: "When applied to man, this law asserts that the individual states in the course of the development of the human embryo, e.g., its existence as a unicellular ovum, as a group of cells after complete cleavage, as a blastodermic vesicle, as an organism without a body cavity, etc., that these stages of development indicate or represent so many animal forms, through which the human species in the course of untold ages has been gradually evolved. The individual states through which the human race has passed in the process of evolution are rapidly rehearsed in its embryonic development. This conception has not passed without challenge. In any case, the comparison of the human development and its individual organs with the corresponding perfect organs of lower vertebrates is of great importance. Thus a mammal dur-

ing the development of its organs is originally possessed of the tubular heart, the bronchial clefts, the undeveloped brain, the cartilaginous chorda dorsalis, and many arrangements of the vascular system, etc., which are permanent throughout the life of the lowest vertebrates. These incomplete stages are perfected in the ascending classes of vertebrates. Still there are many difficulties to contend with in establishing both the evolution hypothesis of Darwin and the biological law of Haeckel." Now if these resemblances between embryos and adults are sufficient to establish the influence of these antecedent forms, they are also sufficient to establish the line of direct descent of the human race. Mr. Darwin says that "in the eyes of most naturalists the structure of the embryo is even more important for classification than that of the adult." By embryology, therefore, we should be able independently to describe the genealogy of man. The resemblance of the fœtus to the adult form must be so definite that it will serve as a guide to phylogeny (development of the species) or the phylogeny will be read into the ontogeny (production of the individual). As the embryo assumes in succession the forms of cell, annelid, fish, dog, ape, it should assume also the whole series of intermediate forms. If the supposition is to be entertained the review must

be complete and the correspondence to antecedent forms clear.

The capital instance and most persuasive argument concerning the structural relations of embryos to ancestral forms is the gill-openings of the human embryo in the fourth week of pregnancy. On either side, extending from the region of the upper jaw, throughout the position of the face and neck there are four graduated openings called visceral clefts, with fleshy rungs between and finished with puffs of tissue. These rungs and prominences are called visceral arches. The first visceral cleft (hyomandibular) penetrates the forward end of the alimentary canal and opens communication with the sac in which the embryo is enclosed (the vitelline sac). The fullness above the first cleft is the rudiment of the lower jaw and the cleft itself becomes the canal which connects the external ear with the pharynx, including the middle ear and the eustachian tube. The second arch or first rung is transformed into the hyoid ligament. The second cleft disappears in the process of the development of the neighboring parts. The arch between the second and third clefts is the rudiment of the thyro-hyoid cartilage. The tube of the thymus gland is formed from the third visceral cleft. The fourth and fifth arches disappear in the formation and extension of the neck,

while the included fourth cleft is applied to form the thyroid gland. All the visceral arches are supplied with blood vessels which arise from the aortic bulb and pass through them from front to rear to unite in a common aorta at the base of the brain.

The importance and suggestiveness of this curious structure which is common to all vertebrates, including amphibia and fishes, is apparent from this sketch of this elaborate and singular structural device. In our common fishes the visceral clefts are six in number and all penetrate the alimentary canal. They, too, have appropriate visceral arches, blood vessels and cartilages. The first cleft also forms the rudimentary element of an auditory apparatus. The bands of cartilage in the visceral arches are the foundations of the radiator system of blood vessels, the gills.

But when we accept this curious structure of visceral clefts and arches as a reminiscence of the branchial clefts of fishes we become involved in serious difficulties with the thesis that the embryo must dramatize the pedigree of the race. Neither at the time when the clefts appear, nor at any other moment of the development of the embryo does it resemble the form or possess the appendages of fishes. When we correlate the clefts with gill-openings the embryo itself falls out of the procession.

Mouth openings are older and belong to more elementary forms than the fishes, but the mouth of the embryo is finally opened (21st day) after the visceral clefts have been formed. Mouth-openings take precedence over gill-openings in the order of evolution, but here in the actual process the mouth-opening is completed after the visceral clefts. The development of the mouth is retarded and the program deranged.

In particular, it is the third and fourth visceral clefts which are associated with the gills of fishes. Gills are breathing organs. These branchial clefts are not employed in the development of lungs. They are used for the formation of the thymus and thyroid glands.

The lungs of higher vertebrates are associated with the swim-bladders of fishes, and the history of this organ is read from the modifications of the breathing apparatus of amphibians. The opening of the swim-bladder occurs at a later moment and in a different location, at the back of the alimentary canal and below the visceral clefts. Considering the lungs as a development of the swim-bladder, the organ must be revolved about the alimentary canal and its opening transposed to make it harmonize with the idea that the lung is a modified swim-bladder.

There are no vestiges of the rudiments of

the more numerous openings of fishes. The two branchial clefts serve to construct the thymus and thyroid glands. The development is forthright. There is no detour. The third and fourth visceral clefts stand in direct relation and perfect structural sequence with the organs in which they are utilized, and the more numerous openings of fishes as directly contribute to the formation of gills.

The visceral clefts and arches, then, are not correlated with the form of the embryo if any of the clefts are rudiments of gills; they derange the program by precedence over the mouth-opening; they depart entirely from the office of gills and the lungs are supposed to represent the swim-bladders of fishes; the third and fourth clefts, branchial clefts, prepare for glands and do not penetrate the alimentary canal. The lungs and their openings must be revolved about the alimentary canal to come to position and neither the gills of fishes nor these last two visceral clefts appear to sustain a rudimentary relation to the other organ.

Long experiences with evolutionary arguments impresses the student with the ability of the hypothesis to sustain the most disastrous fortunes. In embryology it is supported by vague and impaired resemblances in the presence of more gaps than sequences in the schedule of reminiscences. Serious as these

difficulties may be they are not as formidable as a reversal of the order of development of organic forms. The appearance of mouth-openings after the breathing organs inverts the process of evolution. Can the thesis survive its inversion? Is the doctrine proved when the facts stand in a contrary order? Is it verified directly and conversely? As a proposition of reason is it just as credible up side down as right side up?

These questionable resemblances are accompanied with serious omissions, on the part of the developing embryo. In general the embryo departs from the prevailing model of animal structures with their preponderant hinder parts, and in particular some of the most important organic arrangements are disregarded. These are forms which occupy eminent places in the program of evolutionary advance. The mesozoic suarians once had the world to themselves. They ruled almost alone. They are the forebears of vertebrate mammals. With their erectile habits and preponderant after-body they stand in striking contrast to the embryo with its preponderant fore-parts. They have left no mark upon the foetus.

Since the embryo is under the necessity of constant transformation, if the evolution of races was a continuous process, how can the embryo epitomize these gradual changes and

maintain recognizable resemblances? In an infinity of natural forms with many analogies of shape and structure, which analogies are ancestral references? With developed forms provided with identical organs, what references are reminiscent? With a tendency to abbreviate the embryonic process and the consequent obliteration of analogies, with more gaps than sequences and at least one reversal of the order of development, how shall we compare the remnant of degenerated and inverted coincidences? With more precise resemblances where genetic connection is impossible how shall we ascertain the prototype? Other modifications than those observed in the embryo would argue descent from other animal structures; because resemblances are described as partial and indefinite. A fold or crease across the abdomen would be regarded as a marsupial reminiscence. A ridge or fullness between the shoulders would indicate an ungulate tendency to a hump; bosses upon the cranium, the rudiments of horns; a depression or a fissure in the forehead, the foramen of a rudimentary, frontal eye as in anguis, hatteria, etc., and the pineal gland, now a recognized organ of regulative functions, was once described as the aborted optic nerve of such an organ. Nature is so prolific and redundant in forms and structures that a general or particular analogy can be found for

the embryo in some existing or extinct type of animal.

But the species which we know, dead or living, never formed one procession. They have come to their present forms like skirmishers, spreading out in time from a common center all the way from protoplasm; or by successive detachments to right and left of the line of march to form in battle-front. Few precise ancestors of living species are named. Specific marks upon the embryo are as imaginary as "missing links" between species. If anthropoid animals passed through a canine stage of development their ancestor was neither dog, wolf, jackal or coyote. Placental animals, animals which bring forth the foetus alive and complete did not pass through a marsupial form. In their manner of reproduction kangaroos and opossums do not occupy an intermediate stage between egg-laying mammals and placental animals. The latter, the order of animals which not only contain their young but bind them to the mother with a peculiar organ had neither an egg-laying nor marsupial type of mammal ancestor. It is only a generalized form, destitute of precise specific marks with which the embryo is to be compared. Only a mind predisposed for other reasons can find evidence in these resemblances. Unimaginative people can find faces

in clouds. One must have in mind the doctrine of reminiscent embryology to appreciate the evidence. It is "very like a whale." Here is where Prof. Haekel was tempted to tamper with the facts and he fell. When we are further cautioned that species existing and extinct in addition to hereditary resemblances have adaptive resemblances of "analogy" "parallelism," "convergence" and "homoplasmy" (resemblances of different forms due to the same conditions) clear evidence of reminiscence in the development of the foetus is hard to find.

Embryology is a field of research where there is more need of proof to sustain such a hypothesis than science can furnish at present to support the main thesis of evolution. And if human embryology epitomizes the genesis of man, the ontogeny of other species should indicate the phylogeny of their kind. In embryology, therefore, we should see a conspectus of the evolution of the animal world. There are so many resemblances of form and structure in nature where no genetic connection is possible that until some doctrine of resemblances has been formulated the analogies of embryology may reinforce a surmise but they cannot be adduced as proof. Clearness, constancy and multiplicity of resemblances, in the infinite variety of forms and coincidences of morphology are indispensable to mark the per-

sistence of structures which are also in process of change, and, unless the analogies are sufficiently pertinent and evident before the surmise of embryonic repetition to indicate the course of the development of the species, they are probably irrelevant when applied with the hypothesis in mind. Resemblances singly or in multiple between ontogeny and phylogeny for the classification of forms have not served to identify ancestral types or availed for the criticism of evolutionary programs. What degree of analogy, how manifold must the resemblances be to enable us to determine the connection between form and form should be determined in advance of the argument from embrylogy. To pronounce upon the relationship of a given form in a process or series of transformations by foetal analogies is a free use of the scientific imagination.

Much more pertinent are the analogies of embryos among themselves. If, as Mr. Huxley contends, the embryos of man and the dog and of other animals as well can scarcely be distinguished at certain periods of their formation it does not quite follow that this fact is sufficient evidence of the relation of the adult forms. Given bisexual reproduction, with spermatozoa and ova, with ducts and fluids as the means of formation to produce beings with identical organs, there should be similar proc-

esses and persistent structural correspondence. The wolffian bodies, aortic arches and so-called gill-openings are probably necessary for the development of all embryos. The issue is between common structural laws and particular reminiscences. Of the one we have but vague resemblances, of the other incontestible evidence. That we have evidence of both organic reminiscence and common structural laws can be proved only after we have already decided that nature is bound by tradition.

In An American Text Book of Obstetrics we read, "Supernumerary mammae have been observed in many locations, among which the arm, the axilla, various parts of the body wall, the back, the buttock and the thigh are the most conspicuous." Later these supernumerary mammae disappear. Is there here some reference to some extinct ancestor or species which carried the mammae on the arm the buttock or the thigh? Mr. Darwin said, pangenesis and let it go at that.

Two lambs were born on the Tar River stock farm near Wilson, Nash Co., in North Carolina, Feb. 12 and April, 1907, and figured in the Scientific American. They were not malformations nor reversions. They have neither legs nor, so far as can be ascertained, the rudiments of legs. They are sports. Were nature bound by precedent and accumulated tendencies these

structures would be impossible and we could place some confidence in the general analogies of embryonic and foetal forms. With these and similar aberrations in mind we must hesitate to say that ontogeny is a rehearsal of phylogeny. And is not nature wanton when with a single sweep of her hand she cuts away the legs of these lambs, but after millenniums of selection and variation she has not removed the rudiment of the femur of a whale or the atrophied legs and pelvis of the boa-constrictor?

The relation of function and organ is again thrust upon our attention when we turn to the development of the foetus. While the foetus is nourished by the mother, since it has a nervous system of its own, the plan and construction of the animal is deposited with itself. The imperfect embryo at each stage of development is at once the subject and organ of the next state of progress toward the final form. As subject it is incomplete while as instrument it must have a perfection which shall insure the finished form. It combines in itself cause and result. And the result must reside and be guaranteed in its unfinished self. As a being it is incomplete, as an instrument it is qualified to complete itself. The same examination which proves its imperfection reveals the fact that as mechanism it anticipates the perfected form. Unless the pattern and power

exist potentially, that is ideally, we assign at each stage a demonstrated imperfection as the cause of perfection. Unless we can comfort ourselves with the Germ-Plasm Theory we are again thrust out of the organic, sensible world to find a cause in the ideal, functional world. In the effort to account for organic facts functions have become entities and dominate organism.

Great and eminent is the body of medical authority which denies that maternal impressions can directly modify the foetus. J. G. Fisher says, "That traditional superstition has perpetuated the notion, and that the medical profession is in no inconsiderable degree responsible for its continuance; that intense emotions and apprehensions are experienced, and malformations are expected, by many gestating women, yet the abnormal births are extremely rare; that there is no law in the alleged result, and that the occasional apparent relation of cause and effect is due to accidental coincidence." Rarity, lawlessness and accidental coincidence are the phrases by which maternal impressions are set aside as a superstition.

Another authority argues that a hairy malformation, for instance, is alleged to have occurred at a time when the foetus is not in the proper stage of development, in the sixth or seventh month of pregnancy, when it is nor-

mally covered with the vernix caseosa or hairy fell. But if the malformation were then produced it would be described as a remnant of that same lanugo or fell. Only as it occurs at an earlier or later period could it be regarded properly as a malformation. This is another way of setting the facts aside. The occasion is changed for reference to other well known phenomena.

Omitting life-long symptoms of intoxication in men who never drank, too easily attributed to congenital, cerebellal lesions, the case of Daniel Dugas* of St. Jaques, Quebec, 83 years of age deserves attention. The front body wall is cleft, including sternum and pelvis, and the viscera are covered with a membrane. He is unable to sit in a chair or retain urine. He is held together by bandages. This case is not to be explained by amniotic bands. It is not even an arrested development like hare lip or cleft palate, an unfinished natural process. It is a positive cleavage. The family report that the mother, during pregnancy, was called out to view the carcase of a fine, fat hog.

Now, undoubtedly, this case is "rare," we may be positive that there is, "no law in the result," provided we know all about law and life. "Accidental coincidence" is an unsatisfactory judgment after we have been informed

*Note.—Passed away since this was written.

that, "intense emotions and apprehensions are experienced, and malformations are expected, by many gestating women," for these misgivings of the woman and her friends would mark the viewing of the carcase and reinforce the unfortunate impression. The usual explanation that, prepossessed by this "superstition," people search their souls after a malformation has appeared to conjure up an appropriate maternal experience does not apply here; because the incident of the carcase is too notable, and, upon admission of the best authorities, the misgivings of the woman and her friends who have her in charge and influence her, fix attention in advance of birth upon what they consider the occasion of the malformation. Neither disease, lesion, mechanical pressure, peculiar nutrition, nor reversion of type can account for this evidently photo-plastic result of maternal impression.

If we are disposed to speculate and say that nervous energy may be imparted by placental transfusion, or appeal to telepathy, some kind of induction between the major nervous system of the mother and the minor nervous system of the child, the fact of the power of maternal impressions to produce deformities and malformations in defiance of the power of accumulated heredity, a malign power which touches form and organ, ganglion and filament, tissue and

cell against maternal desire and inherited potencies, thrusts us again abroad into a world where functions have the mastery over organism. The functions which we name heredity and strains, as we have seen above, operate in defiance of the generative process when the heredity of a previous act of generation sets aside the legitimate heredity of subsequent acts of generation, that is, the power of telegony demonstrates the dominance of induced functions over the organic process. The latent heredity in the larva (a true worm) of the butterfly is an instance of the existence of functions apart from organism; and the metamorphosis of the adult worm challenges the fundamental contention of many biologists when they assert that ontogeny rehearses phylogeny, the foetus is reminiscent of the development of the species.

CHAPTER IX

BRAIN AND THOUGHT

The center of the visible universe is the human brain. It is also the supreme organism. In the estimation of many it is a step-down transformer of spiritual energy, in the opinion of others it is a marvellous converter of mechanical force. The relations of organ to consciousness is the critical issue of the schools of philosophy. Is the brain antecedent or consequent compared with thought? Here all the art of experiment and all human interest are concentrated. Modern psychology has made us familiar with "brain-tracts, blood pressures, nervous inhibitions, discharges,"—an imposing terminology of speculative physiology and experimental sensationalism. The correspondence of brain-areas with bodily functions has laid the foundation for a vast fabric of mechanical explanations of the physical relations if not of the sources of mental action. There is more conjecture than evidence of correlation of organic conditions and mental states although few would deny that there must be some state of the organ which in some fashion

reflects the states of consciousness. But the issue appears to have been decided in advance of experiment and research. That intention antecedes the state of the organ must be admitted; for if that report of consciousness is untrustworthy what shall we say of every other dictum of the mind, inclusive as well of the judgment that the state of the organ is the cause of the state of the mind? If the mind cannot bear witness to its own states, since it knows objective reality only in conjunction with consciousness, that is, as mental presentations, the observations of physiologists also lose their validity as states of consciousness, that is, as mental presentations. The evolutionist must establish the precedence of the state of the organ. Experience and the conditions of knowledge are against him. Moreover when he has completed his parallels of brain conditions and mental states he is no nearer his goal; for it is impossible to identify nerve currents with forms of thought. The mind has no terms by which to formulate a synthetic judgment which shall unite mental and physiological states in one concept. This is an impassable wall. If thought is but a function of the brain we arrive where the amoeba left us,—the preponderance of function over organ.

Over against all theories of evolution there has been discovered and exploited a whole realm

of theory and experiment which rests upon presumptions which contradict the postulates of mechanist evolution. Hypnotism deals with the mind as a functional, an ideal entity. The organism is persuadable. By auto-suggestion we have neurasthenic patients. By morbid attention the organism deteriorates. By suggestion the hypnotist can induce anesthesia. Faith in the mind as a functional entity is so strong that some practitioners would invoke its power for surgical operations. It is a safer anodyne than chloroform or ether. Some brilliant practitioners in their enthusiasm for their specialty regard the peculiarities and exploits of genius as the performances of neurotic patients. Shakespeare and Dante and Michel Angelo are all psychopaths. Whatever the merits of this pathological view of intellectual excellence and emotional intensity, these practitioners assume the identity, integrity, precedence and dominance of the functions which we name the mind and proceed in experimental fashion to prove that transcendence of the mind by the power of suggestion to determine bodily states. And the stubborn hypnotist will not surrender his faith, facts nor art at the bidding of biologists as he proceeds to lay hold of the organism by its functions.

By the human brain mountains are pierced, the waters and air navigated, the orbits

and constitution of stars determined. Here art, science, philosophy and religion have their seat. Thought and civilization are a partial reflection of its wealth of function. Our laboratories are very busy correlating its conscious and organic states. Evolutionists resent the imputation that they seek neither causes nor reasons. Evolution is proposed as an explanation. It is an attempt to rationalize the universe. The relation between states of consciousness and states of the organ is investigated to discover the nature and cause of thought in organic terms. What the genesis of the brain implies according to the conditions supplied by the evolutionary hypothesis is worthy of particular examination.

If no one understands a reflex neither does anyone understand the organ of reflexes, the ganglion with its filaments. This structure is the working-model and the rudiment of brain. The simplest form under which we may conceive of a structure for reflex action is a looped nerve filament like a hairpin which translates a sensory stimulus into a motor impulse. But the power which shall create a ganglion as the established transformer upon this nerve-circuit is certainly of a different kind from the simple translation of a sensory stimulus into a motor impulse. But that constructive power must be derived from the nerve-current. It must be

a higher function born of the reflex function. It must be a function of that function, a reflex of that reflex. For the formation of a sensorium, of an exchange for these innumerable ganglia and their functions, there must be a reflex of these reflexes. This reflex which is so different from the transformation of sensory stimulus into motor impulse must produce an effect different from itself to make possible that summation of stimuli which is necessary to provide an organ of sense perception. If then cognition arises as a result and mode of sense perception, it is the correlate of another change of the function which erects over the sensorium an organ of cognition. Another set of reflexes of the reflexes of sense perception are necessary to that end. As cognitions are to be united into judgments, and judgments into understanding, and understanding is to issue into self-consciousness, each higher mental process must be in itself and in its organic basis the results of a reflex of reflexes and a product at the same time of a lower form of mental action, that is, of organic action. Briefly, the reflex of the sensory stimulus is the motor impulse. The cause of sense perception must be some reflex of this original and inscrutable reflex and the formative principle of a higher organ. The cognitions which summarize sense perceptions can arise only from a still higher organ created

by these reflexes of reflexes. By the time we arrive at self-consciousness we assume reflexes many times repeated and refined, or rather the original sensory impulse has been raised to the nth power of sublimation. These necessary presumptions of functions of functions, reflexes of reflexes, shadows of shadows overwork the imagination but they are indispensable in the attempt to describe the origin of mind in terms of organic functions. There is an analogy in this exposition of mental action with Mr. Spencer's explanation of the origin of the moral understanding as presentation, representation and re-representation.

There is a remote analogy also between this implied doctrine of reflexes and the known constitution of the nervous system. It is as complex as the telephone service. It has its simple circuits in thousands of elementary units composed of ganglia with their afferent and efferent filaments. There are local, precinct, urban, district and provincial exchanges with a grand central office over all. The elementary ganglia are connected into groups by the filaments of higher ganglia, and these in turn by other filaments are united in larger systems, until the whole structure is unified and controlled in the central office of the cerebrum. The whole multiple system is cross-wired until every circuit and exchange can be connected with every other

exchange or shunted at will. The wiring of the animal organism is beyond the art of the electrical engineer. When we endeavor to explain how sensation is to become thought and self-consciousness in conformity with this hierarchy of nervous systems we are compelled to assume that the process must be this continual super-refinement of reflexes. There is no other source of power or means of its adaptation than the original nerve-current. We encounter other difficulties as grave. One of these difficulties is the fact that the nervous energy is made to control and adapt its organ. Function controls, rather it creates, the organ. Another difficulty is the wonderful substance, the consummate invention which makes Arcturus with all his mass and fire insignificant, the nerve cell. We may try to avoid the extravagance of reflex doctrines and praise the wonderful susceptibility of this supreme substance which is educated into sensation and selfconsciousness in the gray matter of the brain but we have shut our eyes to the wonder we praise. How did it happen that there was such infinite and transcendant susceptibility in any substance? Another difficulty is the subversion of reason. When we can believe that the thing made is superior to that which made it, that the elementary nervous system furnishes the law and power of the higher systems in which it is

bound and controlled, we reject the doctrine of a sufficient cause for every effect. The laws of thought are inverted. Reasoning has all the value of a pun. And, finally, there is the difficulty that the mind as function is not always connected with the organ, the brain. Recalling the fact that the gorilla repeats the human anatomy in all particulars, he possesses the same structure of the brain. He also has the white and gray matter, the two hemispheres, every convolution and lobule which is found in the cerebrum of man. Yet he can neither talk nor think. That function and organ are not necessarily associated is more forcibly illustrated by the human brain. We have a double organ. Each half is a duplicate of the other in every structural particular. In other bilateral or duplicate organs the functions are exercised in common or they may be shifted from one to the other as in the case of a diseased lung or kidney. But brain functions, that is, the mind is not possessed in common by these duplicate hemispheres, nor can it be shifted from one to the other in the event of injury or disease. Like some binary stars, one hemisphere is dark*

* NOTE.—This broad contrast raises a swarm of objections;—Is there no animal psychology? Is there no psychic function apart from speech and the "sensory regions"? What of changes of character due to injury of other areas, also to the "dark brain"? The psychology of formed, logical concepts is meant. Injuries have a

while its companion glows with supernal light. These are two apartments, alike finished, and furnished; but one is shut and locked against all nobler uses and visitation, the other is the hospitable hall of assembly, glowing with use and wont and bustling with the movement and intercourse of many guests. The brain mechanism does not produce mind; for one brain is that of the gorilla, without a gleam of reason. Here organ and function are sundered. And the rational hemisphere is not rational because it is educated by experience. The process is induction rather than education, a drawing in from another realm rather than a drawing out of implicit principles and powers. Thought is not in structure, it comes from without. Here function is not only supreme over organ, it is also transcendant.

The embryo, then, has all it can attend to as it reproduces the animal structure with its specialized organs and systems of superposed and correlated ganglia, nerves, glands, ducts, etc. Embryos which have the same general structure, with the same organs to create should resemble each other and coincidences of form between embryos and adults are inevitable in the degree specified by the doctrine of indefinite and intermittent repetition. In the infinite variety

sympathetic effect upon the entire brain and its functions.

of animal forms coincidences of structure should be numerous. When ages of biological changes are telescoped into minutes resemblances must be doubtful or indefinite. When these resemblances, indefinite at best, occur out of the sequence dictated by the pedigree of the species and reverse the order of the development of parts they prove that the resemblance is accidental. When visceral clefts have a direct structural office, retain no vestiges of additional openings as of gills and occur when the body of the embryo does not resemble fishes, they are also but structural coincidences. Where embryos must resemble each other because they have the same organs to reproduce to ask them also to rehearse their pedigree is a double responsibility. With coincidences in mind and the indefiniteness of the likeness assumed it requires little imagination to read the phylogeny into the ontogeny. Since the plan of growth is resident in the embryo and it spontaneously produces supernumerary mammae anywhere upon the body and lambs are formed without legs by no structural misadventure, and maternal impressions have a direct reconstructive power over the resident forces of the embryo, biological laws have not the stability which warrants such severe induction from vague indications for remote ends as that the ontogeny of an individual rehearses the phylogeny of

species. The mind itself which is to pronounce upon all these relations, considered as the correlate of organic conditions and as but a function of functions is involved in the same necessarian sequence as its organ, the brain, and has no third term by which to adjudge the issue; for mind is but a reflex of reflexes raised to the nth power of sublimation. In magnitude and refinement of conjecture this rehearsal of the pedigree of the embryo comports well with the Germ-Plasm Theory. In the meanwhile the biologist sets up the mind as the umpire and not as the consequent of the vital process and when he admits that the facts of hypnotism are to be taken into account, the mind as function ceases to be relation. Function becomes entity. And we find, as we consider the fact that this functional entity does not establish its seat in one part of the brain, structurally complete for its service, but illuminates its companion, that the mind although it is immanent in the brain also transcends its specialized organ. Function has become transcendant.

CHAPTER X

PROGRAM AND PLATFORM

Physicists take issue with geologists about the platform of evolution. They claim that the hypothesis has been drawn too large for the planet. According to the Nebular Hypothesis the time allowed since the formation of a crust upon the molten globe is all too short. When Lord Kelvin first calculated the age of the crust of the earth he assumed that the melting point of igneous rocks was 7,000°. But we know that they liquify at about 1,800°. By the former calculation geologists might reckon upon anywhere from 20 to 400 millions of years. According to later calculation, from the known melting point of these rocks, there are but 8,500,000 years since the crust of the world began to form. The deposition of Cambrian sedimentary rocks alone requires, according to the statements of geologists, more than the available time if the melting point of igneous rocks is but 1,800°. Prof. Croll reckons 60,000,000 years since the Cambrian age. Mr. Darwin objects that this allowance is far too small to account for the many and complex

forms of life. The maximum limit of time suggested by Lord Kelvin is not enough, and the period reckoned by the known melting point of igneous rocks is a ridiculous proposal. By every computation the earth as a platform for the evolution of life is too small. According to the Nebular Hypothesis, then, the molten globe cools too fast, and the sedimentary rocks could not have been deposited in that time if the world had been the scene of constant floods, glaciers and sandstorms and uninterrupted multiplication of diatoms. These experiments and calculations of the physicists are serious considerations for geologists when they attempt to give account of sedimentary and limestone strata, but they disturb the mutationist only because fossils are imbedded in the rocks. If species are formed as sports, the changes of species at the end of each age gives him little concern as a biologist. There is no law to determine the length, direction or frequency of these jumps. He is prepared for any geological change or cataclysm. In his hands evolution is perfectly flexible if altogether inscrutable as a biological process. He can point to the reality of sports on the one hand, and on the other, to the metamorphoses of insects and tadpoles which by a direct organic process outrun all the differences of species. But he is otherwise involved in difficulties, when he class-

ifies and arranges species in an ascending sequence. Some lower form may have been more plastic than a higher in the same family or the new species may have arisen as a side issue or it may have overleaped some more advanced variety. Serial and multiple resemblances and specific marks lose their pertinence as precise indications of descent.

But the new, Planitesimal Hypothesis of the solar system as a supplement to the Nebular Hypothesis destroys the mathematical barriers of the physicist and gives the geologist and biologist all the latitude they desire, that is, if the hypothesis be very discreetly applied. According to the Nebular Hypothesis with its molten globe there is not time enough for the formation of species by minimal changes, the Darwinian doctrine. According to the Planitesimal Hypothesis the world is formed of cold materials and is heated by the bombardment of aërïolites and the increased compression of gravity. But the accumulation of planetary rubble must be so regulated and distributed that at no time shall the heat of the surface of the earth rise above the melting point of igneous rocks; for, according to the supposition of continual aggregation, the globe once molten, that period of the earth's history would be prolonged instead of shortened. But when the crust is once formed and life has appeared yet

more narrow are the limits of temperature, so narrow indeed that if the range is not less than 200° life will be extinguished. According to one hypothesis the time is too short and according to the other careful management and oversight are necessary to prevent variations of temperature which would be fatal to plants and animals. It is almost as difficult and nice a regard for temperature as the regulation of a hot house. After the crust has been formed the Nebular Hypothesis furnishes a constant temperature for the welfare of life, but an aggregated world must be stoked with discretion. An oversupply or a shortage of fuel may put an end to the biological enterprise according to the Planitesimal Hypothesis.

In the vestibule of the palace of science stand two contrasted figures, one on tiptoe, with floating draperies, brandished timbrel and the flash of a dimpling smile; the other is a squat mass of naked brawn with knotted brow and gripping hands and planted feet,—two images, Beauty and Utility. According to Mr. Darwin these figures were not wedded; they were master and slave, for real beauty there was no utility, and utility alone was the principle of nature. He did not understand the place of beauty in architecture and other constructive arts and in any case he held that the idea was a projection of

the mind not a principle in nature. Beauty for its own sake could not be a natural law. He was right in his reasoning if we submit to his presumption. Beauty is impossible in automatic nature. But when naturalists appealed to the birds, insects and flowers they testified that they had no control of their own splendor. The birds said "Usually we are equally divided in the matter of sex how can we prefer and perpetuate only the more brilliant or the more tuneful." The insects testified that they did not know color, they could not observe it when mating, moreover they did not even mate. If they had any preference their favorite color was green. Moths with their gorgeous colors and patterns fly by night. Their world is dark. To the scientists, therefore, beauty implies design or it is the illusion of our pleasure. And since nature and the principle of beauty are mathematical, that is, rhythmical beauty is a principle both in mind and nature.

This manner of consideration may appear well nigh frivolous to many. Let us put on our achromatic spectacles, strip off the flesh and look at the bones. With barren utility we are at home. Nature who reached down below the useful markings of diatoms and taxed her minimal arts to shame her sunrises and rainbows with the feather of a hummingbird

may play us false in her gravest moment. With some surprise we see that the principle of utility which she employs is neither simple nor directly applied. It is a refined and remote end. Variation presents only complex objects for natural selection. Kinds of utility are discriminated to attain an ultimate good. Immediate advantage is sacrificed. Useless parts are retained. When species should go in light marching order in the struggle for existence, they are burdened with a great margin of safety and duplicate parts. Also nature steps forward and takes the struggle in hand and umpires it. This is the program of natural selection. The right complex variation, at the right time, for long periods, with intermittent severity of trial, for a remote improvement. Meanwhile natural selection must balance progress and regression, specialization and surgery of parts, fertility and sterility, pliability and stability of species. The highly correlated organism is at the same time at war within itself. By these equivocations it comes to pass that the natural doctrine of utility is explained and argued in the precise terms of the discredited doctrine of design. And that the principle of construction is neither simple nor merely utilitarian nature gives good earnest by overspecialization of both forms and structures.

The contradictory application of the prin-

ciple of natural selection is matched by the irregularity and incompatibility of the relations of organism and environment. Plants and animals as higher correlations and automatic centers of environment are now held in structural intimacy with the environment and again they stand apart in stubborn independence. The long shot which the crocodile takes at domesticated species with the tse tse fly for a poisoned arrow is offset by the double environment of eels. Species are sometimes pliant and sometimes rigid. Alien species intrude into the habitat of native flora and fauna, are reinvigorated by the change and evict the indigenous species. The correspondence between organism and environment is so inconstant that no environment is entrenched against invasion.

The more intimate relation of organ and function is inverted at pleasure. Mr. Spencer lays down two propositions which bind them together: 1. "Complexity of function is the correlative of complexity of structure. 2. "Functions, like structures, arise by progressive differentiations." Also he admits the importance of the question, which is cause and which effect. He gives fatal and conclusive illustration of the precedence of function. Undifferentiated energy is no more a means of advance than undifferentiated protoplasm, and

two uncontrolled, undifferentiated factors double the difficulty and insure the futility of the result. A single undifferentiated cause is bad enough, but two such elemental sources guarantee their reciprocal irregularity. If we may once presume, even prove, the precedence of an ideal potential cause the search for the vera causa, the boast of evolution, is doomed to failure, and the reality of ideal causes is established. There is an invisible differentiated world of force over against material forms, and how that has been reduced to order must be ascertained in another fashion than by the methods of naturalistic research. Give function the upper hand and Naturalism becomes Realism.

If we imagine that there is a preponderance of advantage in the conflict of principles exhibited by the exposition of natural selection, the opportunity of progress rests with variation, of which there are two kinds spontaneous and individual, both of which are arrested by Quetelet's law of a constant mean. Only by minimal changes can we analyze and describe the origin of characters, but natural selection must deal with complex variations. These characters also must be coördinated. Variation, therefore, is somatic. It is but a step removed from mutation, which is as inscrutable as the metamorphoses of insects. Inquiry is

particularist, but nature generalizes. The mind begins with analysis, but the facts are synthetic. Mendel's law but reveals the barrier to advance, the dominance of specific over varietal characters. Both schools entertain the notion of repetitious chance, an infinity which turns back upon its own track.

The foregoing unsatisfactory doctrines in their evident failure have forced the discussion out of the field of observation into the realm of infinitesimal conjecture. We see that Mr. Darwin's gemmules and soma-cells were charged with transcendental affinities. DeVries amended that conjecture with biological monads, pangenes. Every nucleus was endowed with all varieties of character germs and with higher functions of superhuman discrimination to qualify each cell according to its position, and with a correspondence between the various cells which should forestall confusion in their combination. But Weismann, after that he had shown that acquired characteristics cannot be inherited, invented microcosm within microcosm, ordered with mathematical rigor and aggregated upon mathematical principles. And after he had exhausted his giant ingenuity in this invention of an epic of the infinitesimal, unexplained relations waited upon other hypotheses as vast and recondite. These germ-theories are the theoretical demonstration of the

impossibility of representing to the understanding the process of automatic evolution. It was sheer intellectual necessity which has driven evolutionists abroad into the ideal world to discover the supreme absurdity, the functional unit, the engram. They have been compelled to exploit the doctrines of Realism and the organic monad.

Not more fortunate have been the efforts of biologists in their examination of the genetic bond. Reproduction is the critical moment of evolution. The organic epitome of structures, the seed, is isolated from the shocks of the general environment. There is continuity of substance between the seed and the mature form. But the organic sequence, the relation which is alone pertinent to development, has been interrupted. The seed, the register and resultant of the experience of plants and animals, has been formed for the vegetal world by an independent transmutation, by metamorphosis. The seed has been mutant but the plant has remained undisturbed by the change. Some animals are reproduced without any organic preformation in the egg which we can discover. Again, the result of innumerable acts of reproduction is surpassed in one forthright, organic process of a single form that larvae may be transformed into imagos. And again, generation reacts upon itself and reproduction is

delegated. The reproductive powers are suppressed yet the species is preserved by the fecundity of individuals segregated from the power of experience and reduced to vegetal idiocy. Finally by the principle of telogeny hereditary strains are transmitted independently of their own germ-plasm.

The remaining effort to verify the genetic bond of species is not more convincing. Do we read the phylogeny into the ontogeny when we suppose that the foetus rehearses the history of its ancestry? The changing embryo with indefinite and intermittent and partial resemblances is at best but vaguely and irregularly reminiscent in its analogies. In the infinity of natural forms it would be strange if there were not many such coincidences. The history of the "branchial clefts" shows that they are not branchial, and they are perfected out of order, before the mouth is completed. Way marks of saurian and marsupial and of the general animal proportions are wanting. Common organs and common structural laws make resemblances between the embryos of different animals inevitable. This view of the genetic bond is secondary to the recognized animal analogies. It must be established after the structural resemblances of the common animal type have been satisfied. Against this hypothesis of a hard and fast animal tradition is the fact that

anomalous animals of fixed species are born. We have, moreover, sports without legs, men with six fingers, supernumerary mammae, and the plastic power of maternal impressions.

Finally by his own reasoning the advocate of automatic evolution is confuted; for if the brain is the supreme achievement of the entire process and mind is but a function of brain, judgment is but a form of the same mechanical force of which it is witness, and its verdict is a self evident fallacy; for it is a resultant of the same process. The intellect is not free. Its decision whatever it be, is a foregone conclusion. The belief that man is the child of lower species and the belief that he is not have precisely the same invalidity. The mind itself as organic function can be explained only by assumptions with regard to the formation of organs by reflex actions which are superposed upon each other to the nth power of sublimation. It will require more than another Germ-Plasm Theory to do the subject justice.

The evolutionary hypothesis is a maze of equivocal propositions. It demands a single principle of exposition, utility, but research encounters the rival principle of beauty, the motive of design. Utility also is not simple. It is applied as a reasoned, an instructed law. Forthright and inverted selection, minimal variations and somatic changes, specialization and

surgery of parts, rigidity and flexibility of species, struggle and isolation, war and truce, coöperation of organs and battle of the parts, chance and repetition are sometimes alternately and sometimes simultaneously in operation. Principles are announced, then conditioned, then amended and yet further modified until they are unwittingly and fractionally repealed. What selection and correspondence with environment cannot do is sought in chance variation; what chance cannot do is amended to mean repetition, and when these expedients fail and acquired characters cannot be inherited appeal is had to molecular precedents, numerical relations and the mysteries of the infinitudes.

The fundamental equivocation is the relation of organ to function. The organ must be supreme. It is entity and function is relation. But functions exist without organic provision and formed organs remain after functions have lost their service. Organs are not rigorously adapted to special functions, that is, functions are more specialized than organs. Again functions are exercised in partnership by organs, that is, organs are more speialized than functions. Functions are often interchanged. The relations of organ and function are inconstant. Different organs are arranged like relay batteries to take upon themselves the duties of

other nerve-centers which have become exhausted. Functions are, further, guaranteed by duplicate parts. Natural selection might account for single contrivances of immediate service to species, if we grant that it can account for anything, but provision for rare and remote contingencies is beyond the scope of an automatic process. Without appropriate organic basis functions range from predominance in the amoeba to supremacy and self-consciousness in the human brain. From the polar globules released from the ovum in preparation for the fertilizing germ to the closure of the foramen ovale of the heart in the moment of change from placental to pulmonary circulation at birth there is constant anticipation and prompt superintendence. Mr. Darwin asumes attractions and affinities and correspondences among cells which imply superhuman cunning under naturalistic terms. DeVries invents a nucleus of universal potentiality with transcendant powers of discrimination and with mutual intelligence for their arrangement in a structure. Function has already become intellectual. Weismann begins with unlimited chance reduced by mathematical aggregation and unanimous multiplication along with incessant struggle and survival but omits what is equally necessary, instant and wholesale extermination of the intractable and sporadic individuals, supplies the

defect of correspondence between cells by an impossible germ-track hypothesis, yet still leaves out of account affinities and correlations of biophors and determinants which cannot be reduced nor analyzed. And constructive functions are resident and sufficient in every embryo. The organism is controlled, invigorated and destroyed by its own functions. Hypnotism may regulate it by suggestion and men die of homesickness. Functions in the hands of naturalists become entity, individuality, personality, spirit. By rigorous attention to organs they prove the reality of immaterial sources of power and control. They demonstrate that automatic evolution does not explain the facts of life, and that it cannot be represented to the understanding in mechanical terms. We begin our investigations with the organ dominant and end with function supreme.

The most remarkable result of the effort to establish universal, automatic evolution is the definition of the process in terms of naturalism. It is formulated from the postulates and discussions of biologists. If natural selection is the law and instrument of organic change the definition should describe evolutionary progress as pure result. That definition is,—Natural selection is directly and inversely applied to plural, complex, coördinated variations, at the right moment, for long periods, in

an environment of irregular correspondence and intermittent stress, for the preservation, accumulation and elimination of natural characters, according to a law of discriminated utility for the formation of species limited by sterility and guaranteed by a margin of safety and duplicate and reinforcing parts. Can there be a better definition of a doctrine of design in terms of Naturalism?

The disaster which has befallen the formulated knowledge with which we won our diplomas is greater than a geological cataclysm. Even our igneous rocks are regarded as sedimentary. Our theories of light, electricity, magnetism, matter, the atom, chemical affinity are gone or going. But for the timely suggestion of DeVries any form of evolutionary doctrine would have been surrendered because it was too big for the world. The contention of this paper is not that there may not be genetic connection between species, but it does deny that the nature, extent and relevancy of that connection with reference to a grand evolutionary process has been made out. It does maintain that the main arguments of the hypothesis have not been confirmed by rigorous analysis or experiment or discovery. The principal contention subversive of organic evolution is that function is often dominant over the organ which is supposed to create it, that the growth and de-

velopment of the individual can be understood only upon the assumption of an ideal world of functions, that is, of plans, potencies and relations which are hereditary without assignable mechanism of transmission; that in the man who reads a yellow slip of paper and straightway faints we have a classic psychological experiment which shows that function controls organism and that it is an entity with independent sensibility and powers, that is, with functions of its own. More briefly stated, this functional argument discloses the fact that organic man cannot be understood without the assumption that he is essentially a functional identity, an ungenerated soul.

As we apply the hypothesis to nature, judged by the hypothesis, nature is often inconsequent, sometimes contradictory and again enigmatical. She will not be bound by our laws. She plays fast and loose with environment, generation, type and individual. She does not adhere to any known rule of heredity. Speculations which distort the object are not highly valuable as interpretations.

Three sources of evolutionary argument should be distinguished,—static, plastic and dynamic biology. The static phase deals with forms and the classification of species; plastic biology, with their formation and modification, and dynamic biology is the account of

the forces which are involved in the transformation of forms, organs and functions. Without plastic biology static biology is a matter of classification only and genetic relations are not implied by the order of species. Without dynamic biology, when static biology has been shown to be plastic, the evolutionary hypothesis has been established, although we cannot describe the action of the forces involved in the process. Static biology is still the stronghold of the doctrine. But the order of static biology is still in process of change and revision. Animals and plants once securely placed break their tethers and roam abroad in the schedule. Persistent and decisive marks are hard to find. Some are more constant than others; all finally fail. The classification is hard to fix. To the Darwinian, with his doctrine of individual variation and minimal changes, specific marks and vestigeal parts are invaluable, but for the rising school of DeVries, with its doctrine that all parts change in a changing individual, every vestige should remain in the degree of its function and specific marks and rudiments are a serious trouble. Now although some sequences of resembling forms are always in doubt and others are broken, what with other sequences proposed and the recovery of new forms which are fitted into the general order static biology

has enlarged the scope of its associations and increased its groups. That some of these sequences are genetic may be true, but with the Lamarckian doctrine of mutation in mind, and with nature executing metamorphoses, the Darwinian hope of a consistent sequences of forms throughout the living world is visionary. With such liberties nature becomes unmanagable on any hypothesis. And against the mutation doctrine the Darwinian instances nascent parts to which the mutationist who is also a somatist cannot reply. Is nature inconstant?

The conversion of static into plastic biology is necessary to establish the hypothesis. Plants and animals are plastic under domestication. But left to themselves domestic species revert to the original, unmodified form and our suggestions are ignored. But if it were possible to establish domestic species we would indeed prove that we possessed the formative principle of nature, and we would have strengthened the suspicion that nature is under intelligent superintendence. We would not have proved that evolution is an automatic process. And since environment as a cause of variation is an assumption "which lacks decisive experiment," since Mendel's law is limited and inconstant, since the reproductive apparatus is modified without change of the mature form, since structures are extemporized

from other than the original material and source, since generation is irregularly applied, since ontogeny must look forward before it can look back and must incidentally and indefinitely produce resemblances to the organic world, since the embryo omits the principal way-marks of animal evolution in its onerous mimetic responsibilities and reverses the order of development of important parts the whole scheme of progress has the appearance of an industriously promoted fallacy rather than a promising working hypothesis. We are compelled to make the brain as the organ of consciousness the result of other inferior functions and treat its functions as entities along with the organs on which it is declared to be dependent. Our working-theory of that genesis implies a system of metaphysics which puts transcendentalism to shame. And man is under arrest. And the apes are under arrest. Pithecanthropos, erectus, decreed a high simian, is under arrest. And all nature is under arrest on the testimony of almost all experimenters. And the hypothesis itself was originally drawn too large for the earth according to the Nebular hypothesis.

If man is the child of lower species his evolution has ceased. For thousands of years he has existed as a domesticated, that is, a protected, a tamed animal, a civilized race. Some

years since several skeletons were exhumed in upper Egypt which archæologists assure us were buried in prehistoric times. The same authorities declare that the men who opened the graves were descendants of the men who were disinterred. After 6000 years the type was unchanged. Scientific opinion concerning the famous Neanderthal skull is undergoing revision. The original verdict was that his race was without religion or customs. He was not properly human and was named accordingly Homo Primogenius. Equal authority rendered similar decisions concerning the skull of Spy and Pithecanthropos Erectus of Java. But the last discovery at Chapelle aux Saint unsettles former conclusions. This anthropoid had a more capacious cranium than his predecessors in point of discovery. He is more ancient. Two years ago he had a muzzle instead of the talking chin and face. He crouched as he walked, as the marks of muscular attachments upon his bones disclosed, yet he was decently interred. He was then too forward in the matter of religious customs to fit into our notions of a consistent evolution of form and intelligence. Either he was wrong or we were. In the meanwhile, as we recall what has befallen early inferences from a few skulls and bones concerning an American glacial race of mankind, we were in a position to

wait for more particular examination of these remains after the first flush of enthusiasm was past. Now he is recognized as man. He had no hairy covering. He did not crouch. Only there is a lingering doubt about his capacity for speech on account of his receding chin and other marks made upon the jaws by muscular attachments. However, his antiquity remains unimpaired. Prehistoric European fragments of skeletons also have been given a different and more moderate interpretation upon second thought. Prof. W. J. Sollas concludes, "The Neanderthal race, the most remote from us in time of which we have any knowledge, and the Australian, the most remote from us in space, probably represent divergent branches of the same original stock." If the antiquity claimed for this Neanderthal race is justified the stability of the human type contradicts the presumptions of evolutionists, mutationists excepted. Dr. Lydekker subscribes to the conclusions of Dr. Sollas. He holds that the Australians are no longer regarded as a lower type of half-breed, oceanic negroes, but a degenerate branch of Caucasian stock.

We have been taught that the tropical sun is responsible for the pigmentation of the negro skin. But generations of residence in temperate and tropic latitudes makes no change

in the color of races. The Brahmin of our Indo-European stock is still a white man. He does not revert or change in the structure of his skin. Even the race types are stable. And wild nature is everywhere under arrest. So nearly complete is the structural pause that the discovery of a single variable species of primrose is the sole reward of the diligence of our armies of naturalists, and that it is a wild species is still dsputed. If there has been evolution the movement is over.

CHAPTER XI

REPLIES

What is the reply of evolutionists to the objections of critics? Prof. Edmund Beecher Wilson in an article entitled Modern Biology contends for mechanistic evolution, and, since the main conclusion of this paper, the dominance of function over organ, depends upon vitalistic arguments, his discussion embodies the reply of his school to the reasonings employed. The strength of his confidence in automatic evolution is indicated when he tells us that "Biological investigators have long since ceased to regard the fact of organic evolution as open to serious discussion. The transmutation of species is not a hypothesis or an assumption. It is a fact accurately observed in our laboratories; and the theory of evolution is only questioned in the same very general way in which all great generalizations of science are held open to modification as knowledge advances." Vitalistic evolution is not entitled to consideration; for, "to me it seems not to be science, but either a kind of metaphysics or an

act of faith." We are, therefore, somewhat surprised at the moderate tone in which he declares the virtues of the mechanist hypothesis. "It is my own conviction that whatever be the difficulties which the mechanist hypothesis has to face, it has established itself as the most useful working hypothesis that we can at present employ. I do not mean to assert that it is adequate or even true." This modesty does not soften his heart toward the vitalistic view. "We find ourselves confronted with wide gaps in our knowledge which open the way to vitalistic or transcendental theories of development. I think we should resist the temptation to seek such refuge." We had thought that belief of the doctrine was a matter of reason and argument, not of personal discipline. But the thermometer continues to fall. "The student of nature can do no more than strive toward the truth. When he does not find the whole truth there is but one gospel for his salvation, still to strive toward the truth. . . . It will be an ill day for science when it can find no more fields to conquer."

We have been told that vitalistic evolution is not evolution, that it is not even science and that it is to be resisted as a temptation, that it is not a proposition of reason. He demands that admitted facts be set aside, for he says, "That evolution has been orthogenetic (the ful-

filment of a definite object in nature) in certain groups seems to be well established, but many difficulties stand in the way of its acceptance as a general explanation." Since the mechanistic hypothesis may not be true and the student can only strive toward the truth and he must guard against vitalism with its admitted facts of orthogenesis, and the quest of science is perpetual, what chance is there that the vitalistic hypothesis will ever obtain a hearing? "Until every other possibility has really been exhausted scientific biology should hold fast to the working program that has created the science of biology." We were assured above that mechanist evolution was "questioned only in the general way in which all great generalizations of science are held open to modification." In another connection he hopes that we may be able to accept this hypothesis in the outcome of research as we have accepted the Copernician theory.

We cannot withold a tribute to the insight and candor of this author in his statement of the facts which are inconsistent with his belief. He does not falter as he presents them. The restoration of the excised lens of the eye of the salamander tadpole is accomplished by a different structure and from different material from that which constituted the original lens. But he forbids any conclusion therefrom in the

interest of his adopted theory. This course is creditable to his foresight and strategy, but it exposes him to the charge in aggravated degree which he prefers against his opponents. His is not a faith, indeed, but it is a form of dogmatic credulity. Why did he not apply the Lamarckian principle of exertion? The optic cup still retaining the functions of response to the lens, as the exuded material fills the hollow of the cup, it continues to exercise its functions, and these partial functions tend to retain and energize the new material. In this manner a responsive function becomes imperative and then creative. Perhaps he considered that when function was regarded as exertion it was transformed into purposive action, something self-centered and determinative. So to argue was to set a Lamarckian trap for himself. He preferred openly to rule out the fact on the strength of his hypothesis.

The regeneration of the lens of the salamander tadpole from other material and by another structure than the ectoderm strikes at the continuity of organs and members, of wings, for example, instanced in the beginning of this paper. Regenerated and extemporized organs cast doubt upon resemblances and sequences on the ground of resemblance. Where there is no biological necessity for continuity the genetic bond is broken. This restored lens is an en-

igma and it is also contrary to the mechanist hypothesis.

Mendel's law is limited in application, he insists, but it works so beautifully as an explanation of sex and heredity that he feels that in the face of hostile facts some way will be found ultimately to extend its application or to discover some mechanistic hypothesis as effective but of more general range. This also is an exercise of faith.

Prof. Wilson claims to abhor metaphysics and we can prove it. He says, "For Agassiz or Couvier the fit is that which is designed to fit. For natural selection pure and simple, the fit is that which happens to fit. I, for one, am unable to find a logical flaw in this conception of the fit." And no wonder is it that he found no logical flaw in that idea of the fit, for there is no logic in it. He has attempted only to bring contradictories together in a synthetic proposition. When applied to an order which must begin in chance it means as a general proposition: Much of what happens fits and whatever fits happens. The logical flaw is a chasm as wide as thought. These assertions may appear to be unwarranted, but let us put them to the test before they are dismissed.

Prof. Wilson would not apply his doctrine of chance as a universal proposition. It is as a limited accidental that he considers the fit.

"It is only one of many possibilities of change." It is not a universal possibility of change. It occurs under organic precedent which limits in advance the range and kind of variability. It is not a pure accidental.

Again, if the variation is in itself accidental it occurs in an environment, that is, in an ordered, related, an adapted field, which by its preponderance and antecedent order can take up the impact and consequences of this already restricted accidental and transform its character. As an accidental it becomes a fitted event by virtue of the coherence and order of the environment in which it occurs. So that the accidental by character becomes the adapted by consequence. Thus from without and by the influence of a contrary assumption on deposit with the environment the alleged accidental is converted into the fit. The fact as an unadapted is put into a mill of adaptation and reduced to conformity. Where also did the ordered environment come from? How did it begin?

Again, each thing, event and change is an accidental considered singly while the environment over against it as a total is adapted. But each thing, event or variation is also in turn a part of the environment of every other thing, event and change. Singly and as subject each thing or event is regarded as acci-

dental, also singly but as object it is regarded as adapted.

Yet again, if each thing in turn is accidental all things as total must be accidental. They have come to be environment, an ordered whole, by an infinity of accidentals. We have, then, the doctrine that the multiple of the accidental is uniformity or, rather, the correlated. Relation is the accident of the unrelated. Structure is a mode of the dissociated.

The writer could conceive of the accidental occurring in the field of the fitted which therefore might fit, only because he forgot that when he considered each element of that field singly he must also make the same supposition for all the elements in turn and thus reduce his total to an unrelated multiplicity. By the power of environment he would transmute the accidental into the related. Some people still contend that the multiple of the accidental is chaos. No, there is no logical flaw in the conception of the accidental as the fit. It is only a denial of the validity of the human understanding. This notion would improve the view of Plate. His coincidences of infinite chance are here supplied with an engine of adaptation in what is already adapted. And by way of reply to the scoff at faith and metaphysics we may deliver Prof. Wilson over to the judgment of August Weismann, who warns

the confident Naturalist that "In each of the principal sciences—physics, chemistry, biology —we always eventually reach a point beyond which observation does not serve us; and the final basis in each science is a hypothetical one." (Con. Rev. Heredity.)

Constant attention to a particular object or a chosen method of investigation may induce the attorney's bias. Long consideration of perfectly valid arguments may overestimate their weight. It is but just that some competent advocate should appear for the defense. One who has read Darwinism To-Day will not doubt Prof. Kellogg's fairness or his mastery of his subject. The conditions, however, which he prescribes in advance of discussion will interest, not to say surprise, lawyers and jurists. These conditions are, First, that the burden of proof shall rest with the opponent. Darwinism is not to furnish evidence. Secondly, in the matter of natural selection variations proper to that end are to be presumed, not argued. Objections from that source are to be regarded as irrelevant. Thirdly, opponents must prove their denial; that is, a negative. Said the darkey to the Tempter, "Gimme yore side er de game and I'll bet er million."

At the outset two assumptions are set aside as not of the substance of Darwinism, namely, "absolute isolation" of species and "independ-

ence of the soma and the germ-plasm." He names eight objections of weight to which he replies as follows:

1. Fluctuating variations are too slight to be of selective value.

"Unfortunately our proof is rather indirect; observation reveals their abundance, but does not actually show their utility. Each naturalist must answer this for himself, and the layman must take the general consensus of opinion of the naturalists, if there is one, for his answer."

2. Linear and quantitative variations do not produce qualitative character.

"These two points, that selection is organismal, and that specializations are as, or more, largely quantitative than qualitative, weaken if they do not abolish all these difficulties of natural selection that are founded on this objection, and it is further necessary to recollect that no specialization has yet been found which has not a primitve counterpart in the earliest known forms of life."

3. Selection cannot produce many-branched descent and discontinuity in series.

"But selection can aid in the differentiation of a species into two or more forms, as the following examples show. When all average or medium-sized individuals of a species are killed out there remain only the smallest and largest

by which, we may assume, that the first are saved because they can most readily conceal themselves, while the latter find in their great size a sufficient protection. On the ground of this difference in size perhaps both forms will be inclined to keep apart from each other, and if to this be added a somewhat different habit of life, two races can arise which in course of time will become distinct species. From a butterfly kind of very variable color-tone all brown individuals might disappear for some special reason while both the lighter and darker individuals might persist. Now if in consequence of this contrast a racial feeling should develop between the light individuals on the one hand and the dark ones on the other, the differentiation into species is already begun."

4. Impossibility of complex, correlated adaptations.

"This objection unfortunately is one which cannot be definitely refuted or proved by ever so much ingenious explaining or discussion in the face of a lack of what we certainly do not now possess, namely, direct observational or experimental evidence. For such specialization as the elaborate mimicry or the electric organ of the torpedo, etc., which are of apparent advantage only in a perfected state, the selectionist is forced to admit that the ob-

jector has apparently a good case, but for the gradual specialization of many highly complex structures and specializations through long-continued selection of slight advantageous variation, Darwin and his followers have offered ingenious and plausible explanations. For the case of so complex and coadaptive a specialization as the eye and its functions in the vertebrates or in the insects and crustaceans, the possible evolution, by slight additions and modifications, from simple pigment-fleck to the present marvellous visual organ, a logically irrefutable Darwinian argument can be made out on the basis of the real and constant utility and advantage of even very slight steps forward."

5. Overspecialization.

"Against the criticism that natural selection cannot explain overdevelopment of specialization; that is, the carrying unnecessarily far of advantageous structural and functional development, as illustrated by the great antlers of stags and moose, the microscopic fidelity of simulation and mimicry, and the nearly identical equivalence of the right and left halves of bilaterally symmetrical animals, the selectionist has little to offer except the always pertinent question: Are we sure that the case in point is one of overdevelopment, of unnecessary specialization?"

6. Degeneration.

"The strict selectionist has no sufficient answer to the objection under present conditions. One seems forced to rely on Lamarckian factors for anything like a satisfactory explanation of actual structural reduction of useless organs."

7. Rigor of selection.

"Here again the proof of the Darwinian point of view is not one so much of observation as it is a proof of reasoning. The fact of an overproduction of eggs and embryos, that is, of reproduction by multiplication, is undeniable. The lack of existing space and food for all individuals if all should live the ordinary span of life peculiar to the species, is demonstrable by mathematics. The consequent conclusion of these two established premises is a struggle for existence."

8. Sexual selection.

"The principal answer of the Darwinians to the criticisms levelled at the theory of sexual selection is, that however ineffective the theory is to explain many of the phenomena it is called on to cover, it is at least so much more reasonable and satisfying as an explanation of some of the phenomena; that is, some of the categories of secondary sexual characters, such as the ornamental plumes and color-patterns of birds, the sound-making organs of in-

sects, etc., than any alternate explanation that has been offered, that until a better explanation be presented the theory of sexual selection should not be discarded."

There is a wide difference between the hard conditions of debate proposed by Prof. Kellogg and his practice when he addresses himself to argument. He accepts the entire responsibility of the defence. Against five of the specifications. 1, The inadequacy of the fluctuating variations; 2, Quantitative variations to produce qualitative characters; 4, Impossibility of complex, correlated adaptations; 5, Overspecialization; and 6, Degeneration, he has no evidence or argument to propose. The three remaining replies, since the author attaches some importance to them, deserve reconsideration. That "selection can aid in the differentiation of species" (3) he insists by a hypothetical case, five removes from reality and observation. If a species of butterfly should meet with the strange misfortune of the extermination of medium-sized individuals; if the remaining forms should, therefore, keep apart; if as a consequence or for some other reason they should acquire a different habit of life; if the two varieties were also somewhat lighter and darker respectively, and if as a result of this contrast a racial feeling should develop between them. "If!" There is humor in the

word "already" in his conclusion from all these conditions in the sentence, "the differentiation into species is already begun." There is another difficulty presented by Mayer's experiments which prove that moths rely upon smell rather than vision.

Rigor of selection (7) he admits is rather a proof of reasoning than observation. There is an overproduction of eggs, seeds and young, but eggs are indiscriminately devoured, and seeds, in as far as any principle of selection is exercised by birds and animals, are more unfortunate. Their enemies eat the best. Predatory animals make short work of the young. Chance of discovery is the only principle of selection applied to them, and unsportsmanlike wolves, bears, tigers and men prefer them. This is the period of life when selection is most effective. What chance has the fawn when his forebears are the prey of eternally trotting wolves, who hunt in packs, chase in relays and are too cunning to turn aside to another track. What difference does a centimeter of girth of a leg muscle make to the baying, persistent pack, the ambushed tiger, the lightning bunt or live snare of the coiled python? With regard to the value of sexual selection (8) the answer is that although it is ineffective it is still reasonable and

satisfying because there is nothing better pro posed.

Evolutionists have everywhere recorded their protest against metaphysics. Prof. Wilson denounces the principles of the understanding, and so eminent an educator as Dr. G. Stanley Hall in his book on adolescence animadverts on Epistemology, the theory of knowledge. The failure of philosophy to solve the fundamental problems of the mind and the world has led to a more rigorous application of the scientific method of observation and a positivist attitude toward all accepted generalizations. Nature must furnish both the facts and method of knowledge, and step by step each generalization was to be built up from the ground of observation and thus replace the older learning with a structure of ascertained truth. Metaphysical criteria were formally, not to say ostentatiously, abandoned. Abstraction must not disturb the patient observations and concrete processes of science. But since metaphysics is implicit in every mental act how is the practice to be avoided? In the new exposition of Naturalism, the Mutation Theory, we read of "heredity" and "character units" and "strains" and "potencies" and "latency," all abstractions. The whole range of natural characteristics

forms, species and their relations and affinities is abstracted, combined and generalized as the outward signs and symbols of a continuous world-process and potency which exists, advances and realizes itself in time and space by means of visible organisms. It is as momentous an exploitation of the supersensible and the abstract as Neo-Platonism or Scholasticism. It is most irrationally metaphysical. It teaches that the homogeneous is the adequate cause of the heterogeneous. The heterogeneous is an ordered homogeneous. The simple produces the complex and the lower the higher, and it follows that the greater is contained in the less. Lower forms of life handicapped by still lower correlations, that is, of environment, refine upon themselves to produce the higher. One inadequate cause hampered by a less adequate becomes all-sufficient. This mode of reasoning is a further application of the doctrine that accident is the unfit, but when it is multiplied by infinity the product is order and progress. Evolution rationalizes the world upon presumptions of irrationality. These repudiators of formal metaphysics are most persistently and reprehensively metaphysical in practice.

One triumph of modern research is a language within a language, the terminology of the natural sciences. It is so extensive and

discriminating that all departments of knowledge can be expressed in its voluminous vocabulary. As science, history, literature and art can be translated into French, German or Italian the whole range of thought can be rendered in the evolutionary tongue.

Human adolescence must repeat the habits of ancestral species. Babies are endowed with a remarkable grip. Little boys (not the girls) climb trees. The eyes of mankind deteriorate because a few of them use glasses. We read, "While individuals differ widely in not only the age but in the sequence of the stages of repetition of racial history, a knowledge of nascent stages, and the aggregate of interests of different ages of life is the best safeguard against very many of the prevalent errors of education and of life." From the platform orator who explains our delight in open fires as inherited taste, the result of ancestral, nomad habits, to Sabatier's Religions of Faith and Religions of Authority thought is translated into the speech of Naturalism. The most visionary association of ideas is recommended as scientifically established. Verification of the hypothesis are encountered everywhere. Like a Comptometer it saves thought. It is the rhetoricians opportunity. We hear of the evotion of the locomotive and the Wright's flying machine. These are all natural phenomena.

They all appear in conformity to biological laws, whether the subject is the growth of language, the progress of civil institutions or an invention. The integration of feudal Europe, and the foundation of the American democracy, the social arrest of China and the awakening of Japan are all exhibitions of uniform natural law and parts of a grand evolutionary sequence. Nothing can be examined without the injection of biological presumptions. Surmise takes the place of research and figures of speech are more potent than reason. It is a German philosophical proposition that history is a science, a natural science. Individually and collectively we do not do the things which we seem to do. We are overborne by automatic, social laws. Our initiative is but submission. Tyranny and revolution, the civil disabilities of Russian Jews and Bunker Hill, seen in their large sociological relations are functions of organic humanity.

We hold fast our confession and when some astronomer thinks that he detects the conditions of life upon Mars he straightway asserts its existence and the phenomenal intelligence of that industrial commonwealth, and sees canals in that Heaven of good civil engineers. Yet here, upon this planet, with known conditions for the support of the multitudinous forms and tribes of living beings the origin of

life is so rare a conjunction of circumstances and forces that some scientists advise an expedition to the Sargasso sea if there we may discover the beginning. Having some conditions upon Mars we are bold to affirm superlatively organized society, and offer a $20,000 prize to encourage communication; with demonstrated conditions here the original plasm was a lucky conjunction of mechanical forces. And these are the assumptions of a science of necessity. On Mars there may be another kind of life, with us there is but one kind, one genetic bond and one center of distribution. Under the same general conditions there cannot be one plasm for Asia and another formed in the shallow seas of archaic America. If there were several beginnings of life it was of the same order or it was crossed and assimilated and advanced according to uniform, biological laws.

But if life is formed when the conditions are provided and is not a lucky conjunction of materials and forces there must be many genetic threads or, we should say, there must be continuous formation of life. If higher species are more rare and more complex and require more specialized conditions than lower forms then the production of life should be the most frequent and evident of facts. Witness the assertion that every planet has the same physical history, and where the conditions are supplied, other

worlds are passing through the same biological periods. They too are populous. They swarm with living, contending, advancing forms. Intelligence, order, morality and an enlightened social state are achieved. They grow cold. The treasure of honor and knowledge vanishes like fairy gold. Their consumptive races migrate to warmer latitudes. Civilization collapses. All bonds are snapped. The contest of degeneration and despair is on until the last, little rush-light of life is extinguished and the planet swings in its bootless orbit, another cinder of the universal furnace.

Finally, the assumption of one family tree for all forms of life, one grand organic sequence of all species, an assumption unproved and inaccessible to research, an assumption maintained in the presence of many contradictory evidences with equivocal propositions, is a faith, if not a superstition, by all the marks of dogmatism, promotion and partiality. It is not established and it cannot be recommended to reason while its advocates are indifferent to what, according to their hypothesis, is the relation of cause and effect, of organ and function.